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REICHSPATENTAMT

PATENTSCHRIFT

№ 640513
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Tag der Bekanntmachung über die Erteilung des Patents: 17. Dezember 1936

Pressed Steel Company Limited in Cowley, Oxford, England

Wagenkasten, insbesondere für Eisenbahnwagen und Omnibusse

Patentiert im Deutschen Reiche vom 16. November 1933 ab

Die Priorität der Anmeldung in Großbritannien vom 18. November 1932 ist in Anspruch genommen.

Die Erfindung bezieht sich auf einen Wagenkasten, insbesondere für Eisenbahnwagen und Omnibusse, der aus mehreren aneinandergereihten, ringartig in sich geschlossenen Abschnitten besteht. Gemäß der Erfindung ist jeder der ringförmigen Abschnitte wiederum unterteilt, und zwar wird jeder der Abschnitte aus voneinander trennbaren Teilen, einem Bodenteil, zwei Seitenteilen und einem Dachteil, gebildet. Die erfindungsgemäße Ausbildung ermöglicht es, die Einzelteile leicht auszutauschen, wenn dies im Falle einer Beschädigung erwünscht sein sollte oder wenn man beispielsweise an einer Stelle, wo sich sonst eine Tür befand, nunmehr einen Abschnitt mit einem Fenster oder einen vollkommen geschlossenen Wandabschnitt anzuordnen wünscht.

Bei den bekannten Ausbildungen bildet jeder ringförmige Abschnitt eine zusammenhängende Einheit. Die Herausnahme einer derartigen Einheit bedeutet dabei eine Zerteilung des Wagenkastens in zwei Hälften. Auch müssen bei der bekannten Ausbildung große verschiedenartige Einheiten bereitgehalten werden, die entweder eine Tür- oder eine Fensteröffnung oder ein Radgehäuse enthalten. Bei der erfindungsgemäßen Ausbildung dagegen sind die verschiedenartigen bereitzuhaltenden Teile verhältnismäßig klein, weil mit einem eine Tür oder ein Fenster oder einen Radgehäuseabschnitt enthaltenden Seitenwandteil die bisherigen Boden- und Dachteile verbunden werden können. Bei der erfindungsgemäßen Ausbildung kann auch durch Verlängerung der Seitenwände nach oben und durch Anordnung von oberen Bodenteilen in einfacher Weise ein zweistöckiges Fahrzeug hergestellt werden.

In der Zeichnung ist ein Ausführungsbeispiel der Erfindung dargestellt, und zwar zeigt

Fig. 1 eine schaubildliche Darstellung eines Wagenkastens eines einstöckigen Fahrzeuges mit den zusammengesetzten Einheiten oder Abteilungen,

Fig. 2 eine schaubildliche Ansicht der einzelnen Teile vor ihrem Zusammenbau,

Fig. 3 eine vergrößerte schaubildliche Teilansicht im Schnitt, bei der einige Teile ausgeschnitten sind, um die Bauart deutlich erkennen zu lassen, und bei der ferner ein Seitenteil entfernt ist,

Fig. 4 einen Schnitt durch die Verbindung zwischen den einzelnen Teilen,

Fig. 5 einen Schnitt gemäß Linie 5-5 der Fig. 4 und

Fig. 6 eine schaubildliche Teilansicht eines Winkels, um die Seitenteile mit den Längsträgern zu verbinden.

Jeder Abschnitt besteht aus einem Bodenteil A, zwei Seitenteilen B oder F und einem Dachteil C. Jeder Seitenteil B besteht aus einer äußeren Verkleidung oder einem Preß-

stück 11, das in dem oberen Teil mit der Fensteröffnung 12 versehen und mit den senkrechten Kanten an nach außen offenen rinnenförmigen Stützen 13 (Fig. 4) befestigt ist, die sich über die ganze Länge der Verkleidung erstrecken. Die Kanten der Seitenwand sind an gekröpften Flanschen 14 der nach außen offenen rinnenförmigen Stützen 13 befestigt. Eine innere Verstärkungswand 15, aus der zur Gewichtsersparnis Teile 16 ausgeschnitten sind, ist an den senkrechten Stützen 13 befestigt und erstreckt sich von der unteren waagerechten Kante der Fensteröffnung 12 bis zur Sitzhöhe. Sie bildet aufwärts gerichtete Streben 25 und einen Querteil 26, die die Ränder der Innenseite der Fensteröffnungen 12 bilden.

Der Bodenteil *A* besteht aus einer waagerechten, gewellten oder ähnlich geformten Wand 17, die an ihren Querkanten mit nach außen offenen rinnenförmigen Teilen 18 verbunden ist. An ihrem Ende ist sie mit senkrecht angeordneten Wänden 19 verbunden, die an ihren oberen Kanten bei 20 zur Bildung der Sitzträger umgebogen sind. Zur seitlichen Versteifung sind Längsstreben 21 in bestimmten Zwischenräumen zwischen den rinnenförmigen Teilen 18 befestigt, während die Wände 17 mit irgendeinem widerstandsfähigen Fußbodenbelag 29 bedeckt sind. Die verstärkten Bodenwände 17 sind so angeordnet, daß sie unmittelbar auf den Fahrgestellträgern 27 aufruhen.

Der Dachteil *C* enthält einen Wandbau aus inneren und äußeren Füllwänden 22 und 23, die im Abstand voneinander angebracht sind. Die Wände sind längs ihrer Kanten an rinnenförmigen, nach außen offenen Teilen befestigt, und zwar in ähnlicher Weise wie der in Fig. 4 veranschaulichte Aufbau der Seitenteile. Die Wände sind ferner durch zwischengelegte Rippen 28 versteift.

Auf jeder Seite und am unteren Ende der Seitenteile 11 sind Tragecken 24 zum Befestigen an den Querträgern 18 vorgesehen.

Die Art der Verbindung der Seitenteile *B* untereinander und mit den Dachteilen *C* und die Art der Verbindung der Dachteile *C* untereinander kann gleich sein und durch die in den Fig. 4 und 5 dargestellten Verbindungen hergestellt werden.

Beim Zusammenstellen eines vollständigen Wagenkastens kann naturgemäß der vordere Abschnitt oder Führerstand *D* entsprechend den jeweiligen Bedürfnissen ausgebildet sein, während die letzte Abteilung *E* gleichfalls gemäß den Erfordernissen und den einzelnen Abteilungen abweichend ausgestaltet sein kann. Zwischen dem vorderen Abschnitt und der letzten Abteilung *D* und *E* werden eine Mehrzahl von gleichartigen, untereinander austauschbaren Abschnitten zusammengestellt, die aus den Teilen *A*, *B* und *C* bestehen, während zwecks Anpassung an die Hinterräder ein Teil *F* benutzt werden muß, der im wesentlichen ähnlich wie die übrigen Teile ausgebildet ist, aber eine Radaussparung 30 aufweist, wie sie in Fig. 1 und 2 veranschaulicht ist. Die Seitenteile *B* können aus Blechpreßteilen bekannter Form gebildet sein, wobei die Außenwand 11 rund um die Fensteröffnung 12 bei 31 umgebördelt ist, um dem Ganzen ein fertiges Aussehen zu geben, während die Innenverstärkungswand 15 eine Abdeckleiste 31′ aufweist, die die Fensteröffnung 12 vollkommen umgibt. Die beiden senkrechten Seiten und die obere Seite des Seitenteiles *B* sind an rinnenförmigen senkrechten Stützen bzw. an einem waagerechten Eckteil in gleicher Weise befestigt. Man erkennt aus Fig. 4, daß die Außenwand 11 und die Verstärkungswand 15 an ihren Rändern umgebördelt sind, um sich den gekröpften Flanschen 14 der Stütze 13 anzupassen. Am unteren Ende der rinnenförmigen Teile ist z. B. durch Punktschweißung ein rinnenförmiger Halteteil 32 befestigt, der an seinen Kanten bei 33 umgebogen ist. Die Flanschen 33 sind in einer der Kröpfung der Flanschen 14 der rinnenförmigen Teile 13 entgegengesetzten Richtung umgebördelt. Die Flanschen 14 und 33 bilden eine V-förmige Rinne für einen noch später zu beschreibenden Zweck.

Jeder Bodenteil *A*, der den gewellten Boden 17, die senkrechten Seitenwände 19 und den Bodenbelag 29 enthält, ist durch Punktschweißung an den nach außen offenen rinnenförmigen Querteilen 18 befestigt. Die Enden der Bodenfläche 17 ruhen hierbei auf stufenförmigen Flanschen 34 der Wand 19 und sind an diesen befestigt. Der Boden 17 erhält mit Hilfe einer Reihe von rinnenförmigen, nach oben offenen Längsstreben 21, die zwischen den nach außen offenen rinnenförmigen Teilen 18 befestigt sind, eine seitliche Versteifung.

Jeder Seitenteil *B* kann beim Zusammenbau mit den üblichen Verschönerungen oder Abdeckungen vervollständigt werden und mit einem Überzug o. dgl. 35 versehen sein, der auf der Innenseite der Verstärkungswand 15 befestigt ist. Die Seitenteile *B* und die Bodenteile *A* werden mit Hilfe von Tragecken 24 (Fig. 6) miteinander verbunden, die L-förmig ausgebildet sind und deren kurzer Arm 51 mit einer V-förmigen Rinne versehen ist. Der lange Arm 52 ist in die senkrechten Stützen 13 eingebettet und durch Bolzen befestigt, wie im folgenden beschrieben werden wird. Das Verbinden der einzelnen Teile zu einem Abschnitt und deren Verbindung un-

tereinander wird in gleicher Weise ausgeführt.

Man erkennt, daß beim Zusammenbau zweier Abschnitte die nach außen offenen rinnenförmigen Teile 13 und 18 zusammen mit den Dacheckteilen sich vollständig um den Abschnitt herum erstrecken und einen Kastenteilbau von hoher Festigkeit und Dauerhaftigkeit bilden. Die Verbindung der Bodenteile kann mit Hilfe von Bolzen 36 bewirkt werden, die unmittelbar durch die Querteile 18 hindurchgehen.

Die Verbindung der Seitenteile *B* untereinander und mit den Dachteilen *C* und die Verbindung der Dachteile *C* untereinander ist in Fig. 4 und 5 veranschaulicht. Die einander offen zugekehrten rinnenförmigen Teile 13 und 32 bilden eine kastenförmige Stütze in der Seite des Wagenkastens und einen kastenförmigen Kopfteil im Dach des Wagenkastens. Die äußeren Wände 11 und 23 sind bei 37 umgebördelt und können ferner noch bei 38 umgebogen sein, um eine V-förmige Kante zu bilden, die sich in die durch die entgegengesetzt umgebördelten Flanschen 14 und 33 der rinnenförmigen Teile 13 und 32 gebildete V-förmige Aussparung einbettet.

Um diese Teile fest miteinander zu verbinden, ist ein streifen- und doppelkeilförmiger Verbindungsteil 40 vorgesehen, der im wesentlichen H-förmigen Querschnitt hat. Ein Befestigungsbolzen 42 durchdringt den Steg dieses Verbindungsteiles. Die Keile 41 greifen in die V-förmigen Rinnen ein und ziehen das Ganze beim Anspannen des Bolzens fest zusammen. Die inneren und äußeren Streifen 40 sind einander gleich. Man erkennt, daß beim Lösen des Bolzens 42 die Verbindungsstreifen entfernt werden können und daß der Teil abgehoben werden kann, ohne in irgendeiner Weise auf die angrenzenden Teile oder auf die Verkleidungen oder Abdeckungen einzuwirken.

Um eine Bewegung der Haltebolzen 42 und hierdurch ein Klappern und Quietschen zu verhindern, sind diese Bolzen in Gehäusen oder Futtern angeordnet, die mit den Stütz- oder Eckabschnitten der Teile aus einem Stück bestehen. Man erkennt aus Fig. 5, daß der rinnenförmige Teil 32 in bestimmten Abständen seiner Länge zu wesentlich dreiecksförmigen, nach außen stehenden Teilen 43 ausgebildet ist, deren Dreiecksspitze mit einer halbzylindrischen Eindrückung 44 versehen ist, so daß beim Aneinanderstoßen der Abteilungen die zusätzlichen Eindrückungen 44 ein zylindrisches Lager für die Bolzen 42 bilden. Auf diese Weise wird eine Bewegung zwischen den Abschnitten verhindert. Die Bolzenköpfe 45 können mit einem verzierenden Abdeckformstück 46 bedeckt sein.

Keinerlei hölzerne Verdeck- oder Abdeckstücke sind notwendig. Hierin liegt ein Vorteil, insbesondere für solche Wagen, die in tropischem Klima gebraucht werden, bei dem Holz einschrumpft oder verfällt und den Wagenkasten im wesentlichen wertlos macht.

Da jeder Abschnitt für sich selbständig hergestellt wird, wird der geringste Lagerraum benötigt, während bei nicht notwendigem örtlichem Zusammenbau die für die Abschnitte benötigten Teile leicht versandt und ohne Schwierigkeiten an dem entfernten Ort zusammengebaut werden können.

Ferner können jedem Wagenkasten als Ersatzteile eine oder mehrere Abschnitte zugeteilt sein für Auswechselungszwecke im Falle einer Beschädigung.

Wie bereits erwähnt, kann die Vorderseite des Wagenkastens entsprechend den verschiedenen Anforderungen ausgebildet und hergestellt sein. Sie kann aber auch in der üblichen Ausführung der Bauart der Abschnitte ähnlich sein. Auch der Schlußteil kann verschieden oder in einer Serienform ausgebildet sein. Hierbei ist die Befestigung der Vorderwand und der Schlußwand mit den Abschnitten dieselbe, wie sie bei der Verbindung der Abschnitte untereinander benutzt worden ist. Der Bau und das Zusammensetzen der Abschnitte kann mechanisch erfolgen, um Irrtümer auszuschließen; die Teile können auch vor dem Zusammenbau zum vollständigen Wagenkasten mit Farbe versehen und auch sonst vollständig fertiggestellt sein.

Es ist zu beachten, daß die Teile eines Abschnittes statt aus Blechwänden auch aus plastischem Material geformt sein können.

PATENTANSPRÜCHE:

1. Wagenkasten, insbesondere für Eisenbahnwagen und Omnibusse, der aus mehreren aneinandergereihten, ringartig in sich geschlossenen Abschnitten besteht, dadurch gekennzeichnet, daß jeder der Abschnitte aus voneinander trennbaren Teilen, einem Bodenteil (*A*), zwei Seitenteilen (*B* oder *F*) und einem Dachteil (*C*), gebildet wird, so daß diese Einzelteile leicht austauschbar sind.

2. Wagenkasten nach Anspruch 1, dadurch gekennzeichnet, daß die gewellte oder ähnlich geformte Grundplatte (17) des Bodenteiles (*A*) auf senkrechten seitlichen Wandteilen (19) aufruht und mit diesen sowie längs ihrer quer verlaufenden Ränder mit zweckmäßig nach außen offenen rinnenförmigen Gliedern (18) verbunden ist, wobei zwischen diesen Gliedern (18) Längsträger (21) eingefügt und gegebenenfalls mit den quer verlaufenden

Wellen der Grundplatte (17) verbunden sind.

3. Wagenkasten nach Anspruch 2, dadurch gekennzeichnet, daß die mit der Grundplatte (17) verbundenen Seitenwandteile (19) längs ihrer oberen waagerechten Ränder zu Sitzunterlagen (20) abgebogen sind.

4. Wagenkasten nach Anspruch 1, 2 oder 3, dadurch gekennzeichnet, daß die zur Bildung der äußeren Wandungen (11 bzw. 22) und der inneren Wandungen (15 bzw. 23) der Seiten- und Dachteile dienenden gepreßten Blechtafeln längs ihrer den benachbarten Dachteilen oder senkrechten Wandteilen zugewendeten Ränder an seitlich offenen rinnenförmigen Pfosten oder Trägern (13, Fig. 4) befestigt sind, wobei die Seitenwandteile die Verglasung und die Polsterung umfassen und wobei zwischen den Randpfosten oder -trägern Längsträger (28) eingefügt sind.

5. Wagenkasten nach Anspruch 2 oder 4 ohne besonderes Traggerippe, dadurch gekennzeichnet, daß die rinnenförmigen, längs der Ränder der einzelnen Teile (*A*, *B*, *C*, *D*, *E*, *F*) vorgesehenen Pfosten oder Träger (13, 18) unmittelbar aneinanderstoßen und längs- bzw. querträger- und querspantenartige Gebilde mit kastenförmigem Querschnitt bilden.

6. Wagenkasten nach Anspruch 5, dadurch gekennzeichnet, daß die Ränder benachbarter Teile (*B*, *C*, *D*, *F*) durch äußere und innere, durch Vorsprünge oder Vertiefungen in Eingriff tretende metallene Leisten (40) und Bolzen (42), die die Kastenwandung vollständig durchdringen, miteinander verbunden sind.

7. Wagenkasten nach Anspruch 6, dadurch gekennzeichnet, daß die Pfosten aus ineinandergepaßten rinnenförmigen Gliedern (13, 32, Fig. 4) bestehen, von deren Rändern zwecks Bildung von nach außen offenen V-förmigen Rinnen in entgegengesetzter Richtung Flanschen (14, 33, Fig. 4) abgebogen sind, und daß in die nach außen offenen Rinnen die Verbindungsleisten (40) mit keilförmigen Randabschnitten (41) eingreifen.

8. Wagenkasten nach Anspruch 6 oder 7, dadurch gekennzeichnet, daß die Bolzen (42) durch buchsenartige, an den aneinanderstoßenden Rändern der Teile ausgebildete Lager (44) hindurchtreten und dadurch die Teile gegen gegenseitige Verschiebung in der Längsrichtung der aneinanderstoßenden Ränder sichern.

9. Wagenkasten nach Anspruch 8, dadurch gekennzeichnet, daß die Lager (44) für die Bolzen halbkreisförmig ausgebildet sind, so daß sie zusammen ein kreisförmiges Lager für den Bolzen bilden und in Form von dreieckförmigen Abbiegungen mit halbkreisförmig eingedrückter Spitze ausgebildet sind.

Hierzu 1 Blatt Zeichnungen

BERLIN. GEDRUCKT IN DER REICHSDRUCKEREI

Zu der Patentschrift 640513
Kl. 20c Gr. 1

Fig. 1.

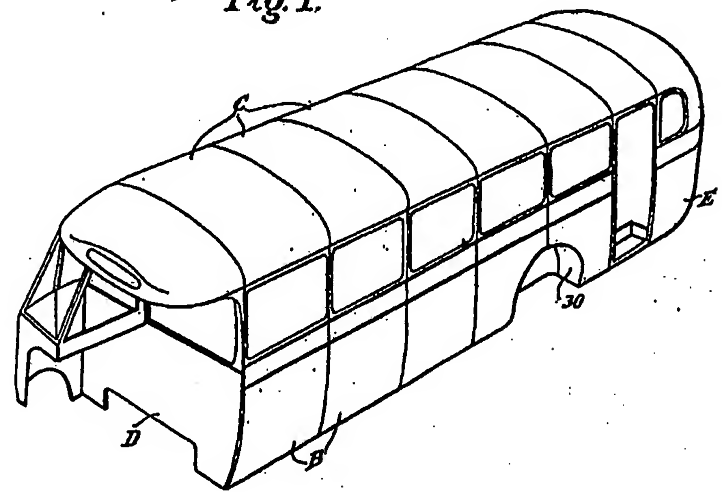


Fig. 2.

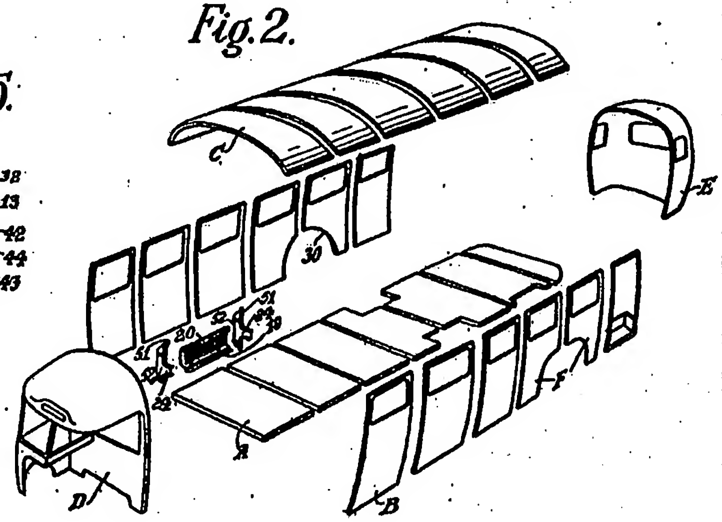


Fig. 4.

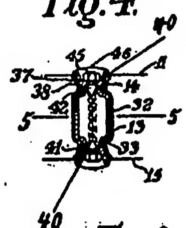


Fig. 5.

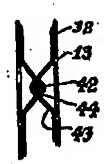
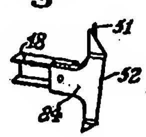


Fig. 6.



Zu der Patentschrift 640513
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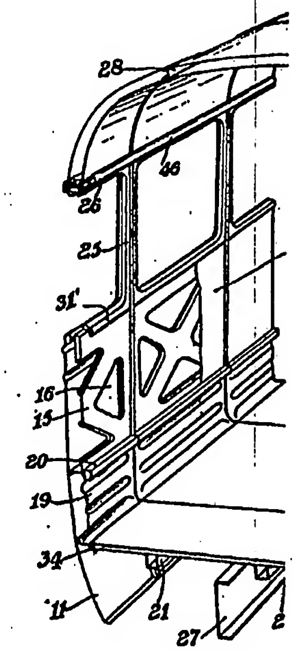

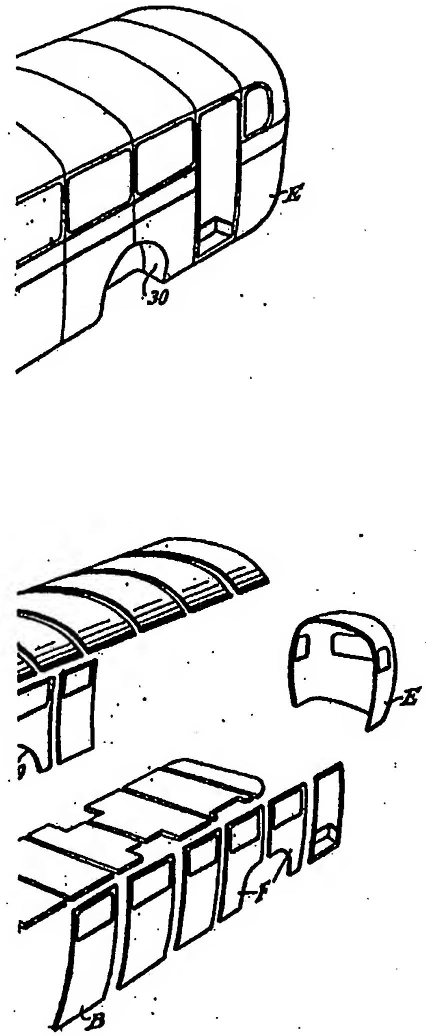

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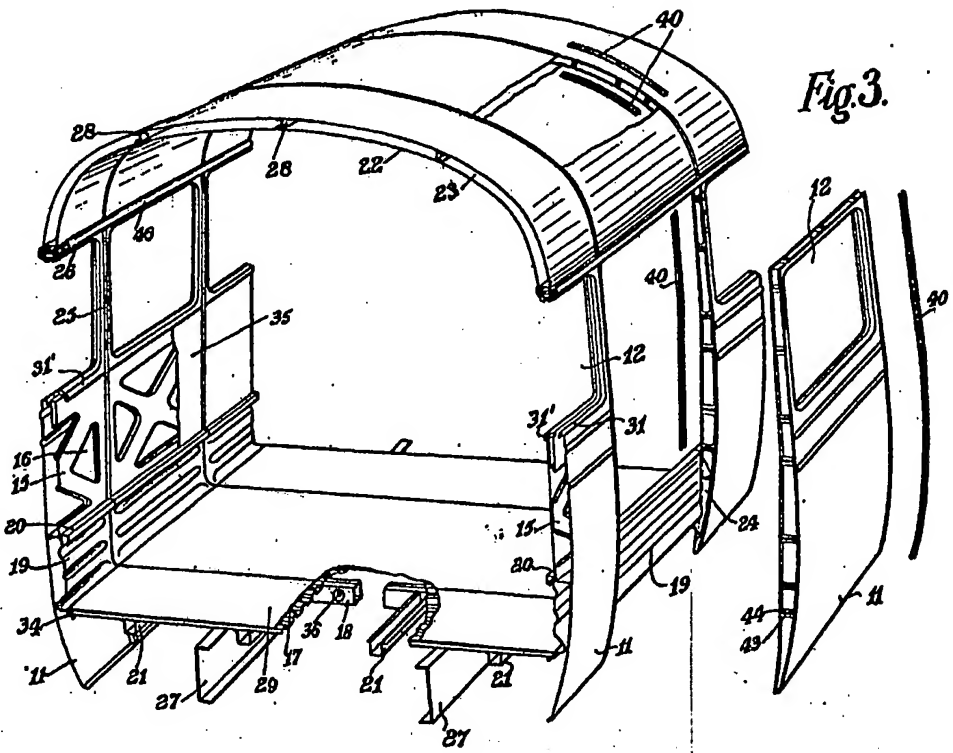
Fig. 3.



Zu der Patentschrift 640513
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Fig. 1.

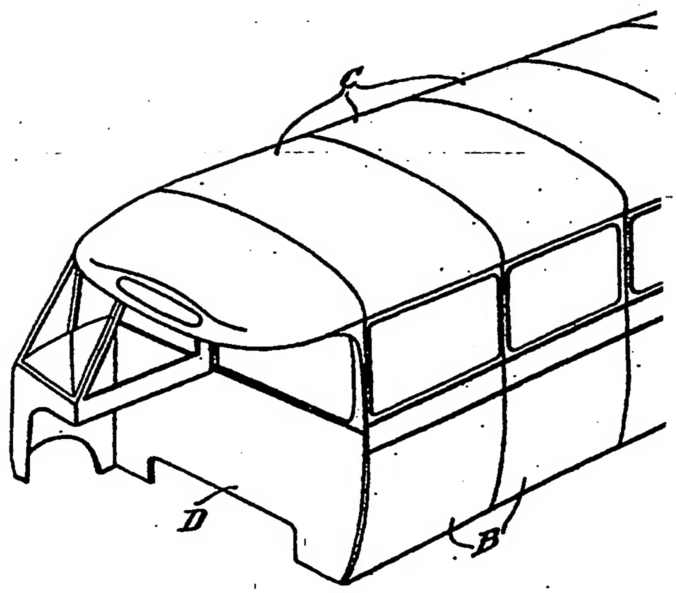


Fig. 2.

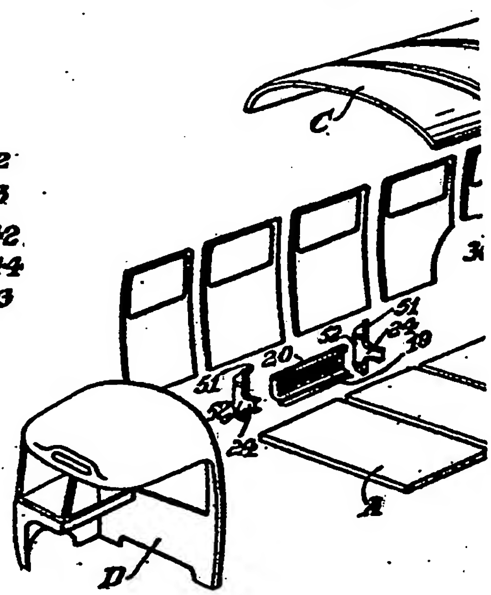


Fig. 4.

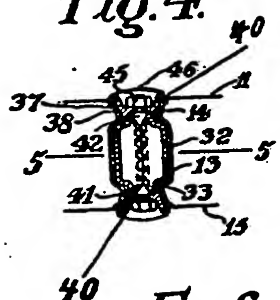


Fig. 5.

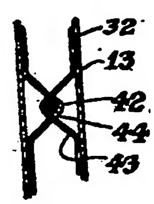
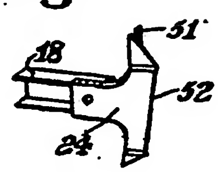
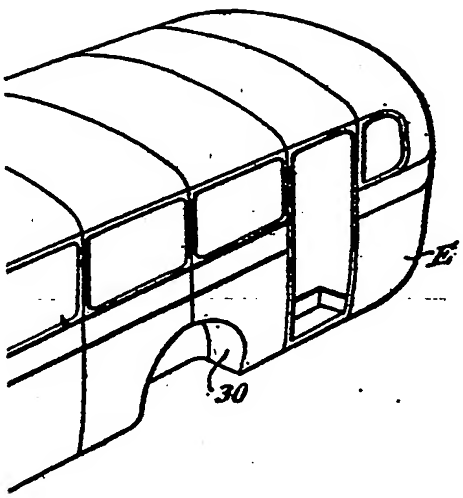


Fig. 6.

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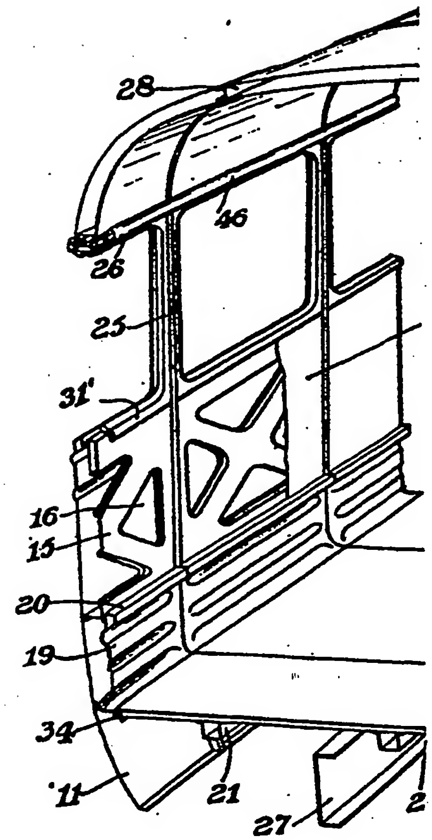
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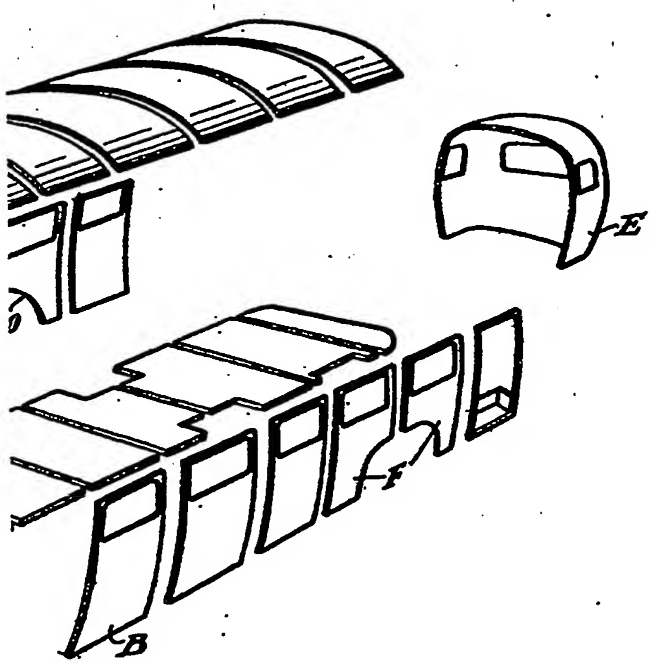
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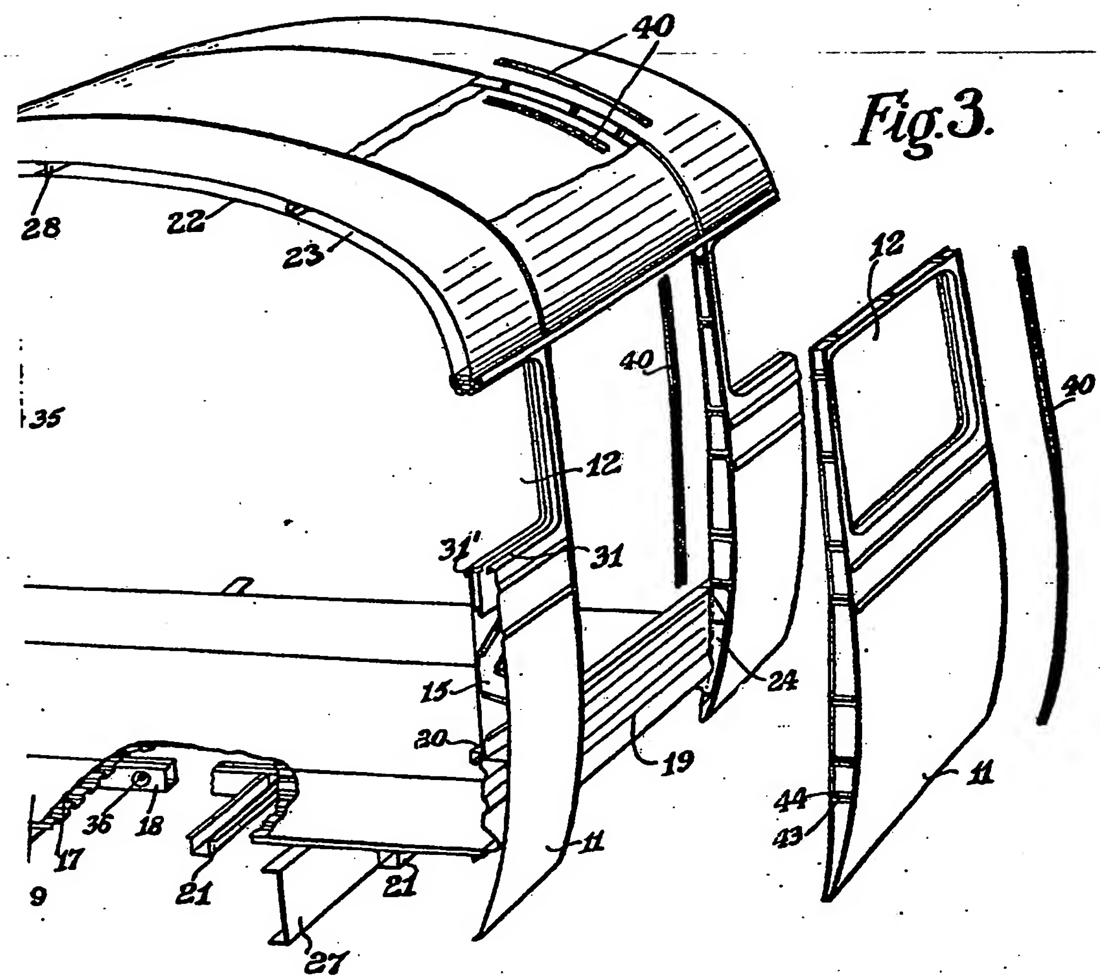
Fig. 3.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PATENT SPECIFICATION

640,513

Date of Application and filing Complete Specification: March 21, 1947.
No. 7859/47.

Application made in United States of America on Oct. 18, 1945.

Complete Specification Published: July 19, 1950.

Under Rule 17A of the Patents Rules 1939-47, the proviso to Section 91 (4) of the Patents & Designs Acts, 1907 to 1946, became operative on June 10, 1947.

Index at acceptance:—Class 106(i), B7, D4b4.

COMPLETE SPECIFICATION

Improvements relating to Calculating Apparatus

We, THE NATIONAL CASH REGISTER COMPANY, of Dayton, in the State of Ohio, and Baltimore, in the State of Maryland, United States of America, a Company incorporated under the laws of the State of Maryland, United States of America, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to calculating apparatus, and is particularly concerned with electronic apparatus in which a product is obtained as a result of the repeated addition of a multiplicand factor in accordance with the value of a multiplier factor.

In accordance with one feature of the invention, an electronic multiplying apparatus includes a multi-denominational totalizer with transfer means between the denominational elements thereof, a cyclically operating impulse generator having associated therewith multiplicand selective devices which are selectively operable in accordance with the digital values of the orders of the multiplicand to direct impulses relative to said values simultaneously into selected elements of the totalizer during each cycle of the generator, means operable after the completion of a cycle of the generator for initiating a transfer cycle through all elements of the totalizer, and means responsive to the conclusion of a transfer cycle for automatically initiating a further entry cycle of the impulse generator.

In accordance with a further feature the invention consists in the provision of a cyclically operating impulse generator, which is caused to be operated in a succession of impulse generating cycles, the number of which is in accordance with the value of a multiplier, under the control of a multiplier unit, and at each cycle to transmit impulses significant of the values of all digits of the multiplicand simultaneously to respective selected denominational elements of a multi-denominational totalizer having, between the elements thereof, transfer means which are adapted to be potentialised during entry operations subsequently to effect transfers, and in which entry operations are adapted to be suspended at the end of each entry cycle until the transfer of all digits by potentialised transfer elements has been effected, after which the multiplier unit is caused to effect a further cycle of the impulse generator in response to the completion of the transfer.

A still further feature of the invention consists in the provision of a cyclically operating impulse generator, a multi-denominational totalizer adapted to receive trains of impulses from the generator significant of the value of a multiplicand, at each cycle of the generator, in several selected denominations thereof simultaneously, adjacent elements of the totalizer having transfer means therebetween which are adapted to be potentialised for subsequently effecting transfers into the element of the next higher order when an element of the lower order passes through zero, and transfer control means operable at the completion of each cycle of the impulse generator to cause potentialised transfer means to effect the transfer of units seriatim between the elements from the lowest to the highest orders thereof, and also to initiate a further cycle of the impulse generator when the cycle of transfer operations has been completed.

A further feature of the invention consists in the provision of a multiplying apparatus in which a product is obtained as a result of repeated entries, each relative to a multiplicand, into a multi-denominational totalizer having transfer

means between the denominational elements thereof, and including a cyclically operating impulse generator for transmitting impulses significant of the value of a multiplicand to selected elements of the totalizer simultaneously at each entry cycle, means operable after each entry cycle to effect a transfer cycle through all elements of the totalizer, a multiplier unit controlling the number of entry cycles to be performed by the impulse generator in respect of each denomination of the multiplier and operable in response to the completion of each transfer cycle to initiate a further entry cycle of the impulse generator, and a control unit operable as entries in respect of each denomination of the multiplier are completed to cause the multiplier unit to control the next series of cycles of the impulse generator in accordance with the next higher demonination of the multiplier and also to operate a distributor unit whereby the impulses of the said next series are directed to the elements of the totalizer of the respective next higher orders to those in which the former entries were registered.

These and other features of the invention will be described in the following description which describes, by way of example, one method by which the invention may be carried out in practice.

The description should be read in conjunction with the accompanying drawings, in which:—

Fig. 1 is a box diagram for use in correlating the remainder of the figures by showing the inter-figure connections.

Fig. 2 shows the multiplicand impulse generator and the multiplicand keys controlling it.

Fig. 3 shows the multiplier unit and the multiplier keys controlling it.

Fig. 4 shows the denominational distributor unit.

Fig. 5 shows the stage control unit.

Fig. 6 shows the units and tens banks of the accumulator.

Fig. 7 shows the hundreds and thousands banks of the accumulator.

Fig. 8 shows the tens of thousands and hundreds of thousands banks of the accumulator.

The Multiplicand Unit.

Referring to Fig. 2, the Multiplicand Unit includes nine digit-representing grid-controlled gaseous discharge electron tubes, numbered "1," "2," "3," "4," "5," "6," "7," "8," and "9," arranged in a potential supply and operative network so that, if a tube of lower value is fired and rendered conducting, the remainder of the tubes of higher value will be automatically rendered conducting one at a time in sequence, ending with the tube representing "9." If a positive electric impulse is impressed on terminal 100, it will cause the "1" tube 101 to become conducting, which act in turn causes the "2" tube 102 to become conducting, and so on until the "9" tube 103 is rendered conducting, after which the "Transfer Initiator" tube 104 is rendered conducting. Each of these conducting tubes almost immediately becomes extinguished in a manner to be explained. As each digit tube or the tube 104 fires, its cathode becomes more positive in potential, due to a resistance in each cathode supply circuit, and such rise in potential is used as a positive potential impulse impressed on an associated output conductor, such as conductor 105 associated with the "1" tube. The positive impulse of the "Transfer Initiator" tube 104 is impressed on conductor 106.

Each impulse output conductor, like conductor 105, is connected through a rectifier like rectifier 107 to a terminal point like point 108, said rectifier being oriented to pass positive potential impulses originating at the associated cathode toward the point 108 but not in a reverse direction. Points like points 108 and 109, connected to the cathode of the "2" tube through rectifier 110, are connected by a rectifier like rectifier 111 oriented to pass positive potential impulses from point 108 toward point 112 but not in a reverse direction. Rectifiers like rectifiers 107 and 110 are provided to prevent dissipation of produced impulses among the nine cathode supply systems.

Anode potential is supplied to the tubes of Fig. 2 from a 115-volt positive source 113 through resistor 114 of 250 ohms, point 115, resistor 116 of 500 ohms, and point 117. Point 115 is coupled to ground through .5-microfarad stabilizing capacitor 118. The anode of "Transfer Initiator" tube 104 is connected to point 117 directly, and the anodes of the digit-representing tubes are connected to point 117 through a 3,500-ohm resistor 119.

The cathode of the "Transfer Initiator" tube 104 is coupled to ground through 50,000-ohm resistor 120 in parallel with .001-microfarad capacitor 121. Each of the cathodes of the digit-representing tubes is coupled, as shown with regard to the "9" tube 103, on one side to ground through a 15,000-ohm resistor like resistor 122 in parallel with a .001-microfarad capacitor, like capacitor 123, and on the other side to negative 150-volt conductor 124 through a 150,000-ohm resistance, like resistor 125, a point

like point 126, and a 300,000-ohm resistance like resistor 127.

The control grid of each tube except the "1" tube 101 is biased by connection to the cathode supply network of the previous tube of the series. Thus the "Transfer Initiator" tube grid 128 is connected through 500,000-ohm resistor 129 and point 130 to point 126. In a similar manner, grid 131 of the "9" tube is connected through 500,000-ohm resistor 132 and point 133 to point 134 in the cathode supply circuits of the "8" tube 135.

Each digit tube grid, excepting the grid of the "1" tube, is coupled through a point, like point 133 of the "9" tube grid supply, to negative potential supply conductor 124 through a .001-microfarad timing capacitor like capacitor 136. "Transfer Initiator" tube grid 128 is connected through point 130 and .001-microfarad capacitor 137 to ground. These capacitors are for timing only, preventing the too rapid firing of the tubes in sequence. Obviously, the "1" tube 101 needs no such timing device because it is the first tube to fire.

The grid of the "1" tube is biased by being connected through resistor 138 of 500,000 ohms to point 139, which is connected on one side through 50,000-ohm resistor 140 to ground and on the other side through 250,000-ohm resistor 141 to negative supply conductor 124.

Under the circumstances given, the cathode of "1" tube 101 is normally at about 5 volts negative with respect to ground, its grid is about 25 volts negative with respect to ground, and the anode is about 115 volts positive with respect to ground. The other digit tubes of Fig. 2 normally have the same anode-cathode potential but have a normal grid potential of about 50 volts negative with respect to ground. The "Transfer Initiator" tube 104 has the same grid and anode potentials as the tubes "1" to "9," but its cathode is connected only to ground, as it is unnecessary to provide a potential-dividing network for grid-priming another tube, it being the last tube of the series to fire.

A positive potential impulse of sufficient potential to fire the "1" tube 101 is supplied to input terminal 100 (see Fig. 3 for its origin) whenever the impulse generator of Fig. 2 is to be given a cycle of operation. Such impulse comes from the Multiplier Unit shown in Fig. 3 and to be described hereafter. As the "1" tube 101 fires and becomes conducting, the anode supply conductor 143, due to resistors 114, 116, and 119, drops in potential to within about 15 volts of the normal cathode potential of 5 volts negative as cathode-ground capacitor 142 charges. As capacitor 142 becomes charged, the potential of the cathode of the "1" tube rises to a point determined by the resistors 114, 116, and 119 in the anode supply circuit, the potential drop of 15 volts within the tube and the cathode resistors 144, 145, and 146. Thus the cathode of "1" tube 101 rises from 5 volts negative to about 77 volts positive with respect to ground, impressing an impulse on point 108. Point 147 changes from 50 volts negative to about 1 volt positive, and the grid potential of the "2" tube 102 during this times rises to a point where the "2" tube fires and becomes conducting. The anode supply conductor dips in potential to about 10 volts as the associated cathode-ground capacitor charges, causing the extinguishment of the "1" tube 101, as its anode potential drops below the cathode potential, which is momentarily maintained at about 77 volts by the charge in capacitor 142. In the same manner, the "3," "4," "5," "6," "7," "8," and "9" tubes fire successively, each tube as it fires extinguishing the preceding tube of the series. The "Transfer Initiator" tube 104 then fires, as its grid is connected to point 126 in the cathode supply circuit of "9" tube 103. This extinguishes the "9" tube as the potential of point 117 drops to 10 volts momentarily as capacitor 121 in the cathode supply circuit of the "Transfer Initiator" tube 104 is charging. It will be observed that, while the digit tubes "1" to "9" have 4,250 ohm resistance in the anode supply circuit, due to resistors 114, 116, and 119, the "Transfer Initiator" tube 104 has only the resistors 114 and 116 in its supply circuit, amounting to 750 ohms, and only the 500-ohm resistor 116 between it and the .5-microfarad capacitor 118. As a result, while capacitor 121 is charging, there is a very high current flow through the "Transfer Initiator" tube 104, which is abruptly reduced as capacitor 121 becomes charged. The distributed inductance in the supply circuits for this tube, as the current suddenly reduces, causes an oscillatory rise in potential of the cathode, and momentarily there is a cessation of current flow in the tube, causing it to self-extinguish. However, during its brief period of conductivity, it produces a positive potential impulse on output conductor 106 and termianl 148 (see also Fig. 6), which initiates a discharge in "Transfer Control" tube 439 (Fig. 6), the purpose of which will be explained.

As the Impulse Generator digit tubes "1" to "9" (Fig. 2) fire successively,

the cathode rise in potential of each is impressed on associated points such as points 108 and 109, all being propagated in one direction toward point 112. It follows that point 108 receives one impulse, point 109 receives two impulses, point 150 receives three impulses, and so on, point 112 receiving nine impulses.

For each impulse-receiving point such as point 150, there is provided a conductor, such as conductor 152, provided with a plurality of key switches, in this embodiment three in number, 153, 154, and 155. Swith 155 represents three in the units decimal denomination 10^0 and, when operated, connects conductor 152 to output conductor 156, representing the 10^0 denomination. Similarly, switch 154 represents three in the tens decimal denomination 10^1 and, when operated, connects conductor 152 to the output conductor 157, representing the 10^1 denomination. Switch 153 connects conductor 152 to output conductor 158, representing the hundreds denomination 10^2. Therefore it is possible to operate a key in each selected denomination, and, when the digit tubes "1" to "9" operate a cycle by firing in succession, the various output conductors receive a number of impulses corresponding to the value of the associated operated key. Resistors of 100,000 ohms such as resistor 159 connect each output conductor to ground to permit recovery of the conductor after receiving an impulse.

Repeated cyclings of the impulse generator, assuming that the selected keys are kept operated during such cyclings, result in the same pattern of impulses being repeatedly impressed on output terminals 160, 161, and 162 (see also Fig. 4). One cycle of the impulse generator corresponds to a single entry of the multiplicand factor, which is directed by the Denominational Distributor of Fig. 4 to the Accumulator of Figs. 6, 7, and 8 by means of terminals 170, 171, 172, 173 and 174 (Figs. 4, 6, 7, and 8) according to the stage of the multiplying operation, which is determined by the Stage Control unit of Fig. 5 in its effect on terminals I, II, and III (see Fig. 4 also). The Stage Control unit of Fig. 5 at the same time determines which digit of the multiplier factor set up on the keys of the Multiplier unit of Fig. 3 controls the recycling of the Impulse Generator of Fig. 2.

It is obvious that the impulse impressed on terminals 160, 161, and 162 by the firing of the "1" tube 101 will occur at the same time (assuming a key to have been operated in each bank) and the same is true for the output on each digit tube. It is obvious, therefore, that impulses occurring on the several conductors 156, 157, and 158 simultaneously are sent to the accumulator, and entry of data in the several orders of the accumulator may be going on simultaneously, necessitating a pause between each cycling of the impulse generator to give time for transfer of carry-over data.

Carry-over data in the accumulator is transferred successively by denominations, commencing with the lowest denomination, and the transfer operation occurring between cycles of the impulse generator is initiated by the "Transfer Initiator" tube 104 (Fig. 2), which sends a transfer starting impulse over conductor 106 and terminal 148 (see Fig. 6) to the 10^0 denomination of the Accumulator. On completion of the transfer operation, an impulse is impressed on terminal 175 (see Figs. 3 and 8), which, through the Multiplier Unit of Fig. 3, causes a recyclin- of the Impulse Generator (Fig. 2) through a positive impulse impressed on terminal 100 (Fig. 2) through capacitor 176 of .00002 microfarad to the grid of the "1" tube 101.

Therefore, the Multiplicand Unit of Fig. 2 always stands ready to issue a selected number of impulses, as determined by the operated Multiplicand keys, on each of output terminals 160, 161, and 162, when a positive impulse is impressed on terminal 100.

Capacitors, like capacitor 177, before described, of .001 microfarad slow down the operation of this impulse producer to about 10,000 impulses a second, and therefore one cycle of its operation of the ten tubes consumes about .001 of a second. The Accumulator functions much faster, the difference in speed being deliberately provided so that the generated impulses will not exceed in speed the acceptance rate of the Accumulator.

It will be readily perceived that there can be as many key banks in the Multiplicand Unit as desired without increasing the number of tubes.

THE DENOMINATIONAL DISTRIBUTOR.

As stated before, the particular embodiment of this invention discloses three multiplicand denominations and three multiplier denominations.

In the Denominational Distributor unit shown in Fig. 4, the three horizontal rows of tubes represent the multiplicand denominations, and the three vertical columns represent the three multiplier denominations.

Thus, tubes 180, 183, and 186 represent the units multiplier denomination, tubes 181, 184, and 187 represent the tens multiplier denomination, and tubes 182, 185, and 188 represent the hundreds multiplier

denomination. For purposes of convenience, these units, tens, and hundreds denominations are termed stages I, II, and III, respectively.

Tubes 180, 181, and 182 represent the hundreds multiplicand denomination, tubes 183, 184, and 185 represent the tens multiplicand denomination, and tubes 186, 187, and 188 represent the units multiplicand denomination. These have been denominated as 10^2, 10^1, and 10^0 denominations, respectively.

Output terminals are provided, as has been described, representing 10^0, 10^1, 10^2, 10^3, and 10^4 denominations and are numbered 170, 171, 172, 173, and 174, respectively.

An impulse issuing from the impulse generator and impressed on terminal 160 is arranged to fire either tube 186, 187, or 188, depending on which one of stage control terminals I, II, or III is energized. I terminal 190 energizes or primes tubes 180, 183, and 186; II terminal 191 primes tubes 181, 184, and 187; and III terminal 192 primes tubes 182. 185, and 188. If I terminal 190 was primed as the impulse was received on terminal 160, representing 10^0 power of the multiplicand, then tube 186 would fire and become conducting and in so doing would issue an impulse on diagonal output conductor 193, ending in 10^0 terminal 170, which is the input to the 10^0 denomination of the accumulator (see Fig. 6). If. instead, the II terminal were primed, the tube 187 would fire and the output would be on conductor 194, connected to the terminal 171, which is the input to the 10^1 denomination of the accumulator. If the III terminal 192 were primed, the tube 188 would fire and the output would be on conductor 195, which is connected to the terminal 172, which is the input to the 10^2 denomination.

It will be seen that conductor 193 has only the cathode of tube 186 connected thereto, conductor 194 has the cathode of tubes 183 and 187 connected thereto, conductor 195 has the cathodes of tubes 180, 184, and 188 connected thereto, conductor 196 has the cathodes of tubes 181 and 185 connected thereto, and conductor 197 has the cathode of tube 182 connected thereto. The following table discloses the routine of the impulses in different stages of a multiplying operation.

Generated Impulses Impressed on Terminal	Distributed to Accumulator Terminal
Stage I	
160—10^0	170—10^0
161—10^1	171—10^1
162—10^2	172—10^2
Stage II	
160—10^0	171—10^1
161—10^1	172—10^2
162—10^2	173—10^3
Stage III	
160—10^0	172—10^2
161—10^1	173—10^3
162—10^2	174—10^4

Each of the Denominational Distributor tubes is arranged in a circuit that makes it self-extinguish if it fires, just as was explained in connection with the "Transfer Initiator" tube 104 (Fig. 2). All the tubes connected to the same diagonal output conductor have the same cathode supply circuits. The cathode of tube 186 is connected to ground by 50,000-ohm resistor 198 in parallel with .0005-microfarad capacitor 199. The cathode is also coupled to the output terminal 170 by the .01-microfarad capacitor 200.

In a similar manner, the cathodes of tubes 183 and 187 are connected to ground through resistor 201 in parallel with capacitor 202, and coupled to terminal 171 by capacitor 2030. The other cathode connections are similar and can be traced as follows: the cathodes of tubes 180, 184, and 188 are connected to ground by resistor 203 and capacitor 204, and coupled to terminal 172 by capacitor 205; the cathodes of tubes 181 and 185 are connected to ground by resistor 206 and capacitor 207, and coupled to terminal 173 by capacitor 208; and tube 182 is connected to ground by resistor 209 and capacitor 210 and is coupled to terminal 174 by capacitor 211.

The anodes of all the tubes in a horizontal row are supplied from the same terminal. For instance, the anodes of tubes 180, 181, and 182 are supplied with 75 volts positive potential from source 212 through resistor 213 of 250 ohms, point 214, and resistor 215 of 500 ohms. Point

214 is coupled to ground through capacitor 216 of .1 microfarad. In a similar manner, terminal 217 supplies anode potential to tubes 183, 184 and 185, and terminal 218 supplies anode potential to tubes 186, 187, and 188. With these circuit elements, when a tube fires, it automatically extinguishes because of the high initial current followed by an oscillatory rise in cathode potential as the associated cathode-ground capacitor becomes charged. As a tube fires, the positive rise in cathode potential is impressed on the associated output conductor.

The grids of all the tubes are normally heavily biased by reason of potential applied from the stage control unit of Fig. 5. Thus the tubes 180, 183, and 186 (Fig. 4) obtain their grid bias from I terminal 190 (see also Fig. 5); tubes 181, 184, and 187 obtain their grid bias from terminal 191; and tubes 182, 185, and 188 obtain their grid bias from terminal 192. This normal grid bias is 80 volts negative, but is relieved to 35 volts negative when in the primed state. For example, under normal circumstances, when stage I of the multiplying operation occurs, terminal 190 changes from 80 volts negative to 35 volts negative, which change is impressed on the grids of tubes 180, 183, and 186 each through a 500,000-ohm resistor, like resistor 219, a point like point 220, and and a 50,000-ohm resistor, like resistor 221. Points like point 220 are coupled to the associated input conductor. Thus, point 220 is coupled to conductor 222 through a .00002-microfarad capacitor 223. If an impulse signal is received over any of terminals 160, 161, and 162 while I terminal 190 is primed, the corresponding ones of tubes 180, 183, and 186 will fire and self-extinguish, each firing of a tube passing on an impulse to the associated output conductor. Terminals I, II, and III are rendered primed in sequence by the Stage Control Unit, and each stays primed until the Impulse Generator operates a number of times equal to the value of the corresponding operated multiplier key switch.

Stage Control.

The Stage Control is shown in Fig. 5 and comprises a start tube 250 and three stage control tubes I, II, and III, numbered 251, 252, and 253, respectively.

The cathode of Start tube 250 is connected to ground through 50,000-ohm resistor 254. Its grid is connected through 50,000-ohm resistor 255 to points 256 and 257. Point 257 is connected on one side through 500,000-ohm resistor 258 to negative 150-volt supply conductor 259, and on the other side through 350,000-ohm resistor 260, point 261, 5000-ohm resistor 262, point 263, 250-ohm resistor 264, to Start Key Switch 265, which, when closed, makes contact with 115-volt positive potential terminal 266. Point 263 is coupled to ground by .5-microfarad capacitor 267 for stabilizing purposes, and point 256 is coupled to ground by .01-microfarad capacitor 268. When capacitor 268 charges, as key 265 closes, the grid of Start tube 250 loses control, and the tube fires, causing a potential rise at its cathode which is impressed on point 270 through .00005-microfarad capacitor 271. The anodes of tubes 251, 252, and 253 receive their potential from point 263 through 3,000-ohm resistor 272. During the slight delay of perhaps .001 second, while Start tube 250 is firing, the potential supply network of the I, II, and III tubes 251, 252, and 253 become stabilized, as do the bias voltages delivered to the grids of the tubes of Denominational Distributor of Fig. 4, through terminals 190, 191, and 192. The cathode of each of tubes I, II, and III is connected on one side to ground through a 15,000-ohm resistor, like resistor 273 in parallel with a .002-microfarad capacitor, like capacitor 274 in series with a 1,000-ohm resistor, like resistor 275, and is connected on the other side to negative 150-volt conductor 259 through a 100,000-ohm resistor, like resistor 276, a point like point 277, and 100,000-ohm resistor like resistor 278. The grid of the I tube 251 is connected through 50,000-ohm resistor 280, point 270, 500,000-ohm resistor 281 to point 282 connected to ground through 50,000-ohm resistor 283, and to 150-volt negative conductor 259 through 250,000-ohm resistor 284. The grid of the II tube 252 is connected to and receives its bias from point 277, which is relieved when I tube 251 is conducting, so that a positive potential impulse impressed on conductor 285, which is coupled to the grids of tubes II and III, each through a capacitor like .00002-microfarad capacitor 286 connecting to point 287 of the II tube grid circuit, will fire the II tube and not the III tube. The normal grid bias of tubes II and III with respect to the associated cathode is about 80 volts negative and, when primed by reason of conduction in the preceding tube, is about 35 volts negative. The firing impulses on input conductor 285 are adjusted to fire a primed tube only. Thus, the sequence operation of the Stage Control Unit of Fig. 5 commences with the firing of the Start tube 250, and after a short interval, during which the supply networks adjust themselves, the I tube 251 fires and becomes conducting. This act causes a rise in

potential of the cathode of the I tube, as has been explained, which primes the grid of the II tube. This priming potential is also impressed through point 288 and conductor 289 to terminal 190 (see also Fig. 4), which primes the grids of the I column of Denominational Distributor tubes 180, 183, and 186 (Fig. 4). The rise in potential of the cathode of the Stage I tube 251 (Fig. 5) is also conveyed by conductor 290 to terminal 291 (see also Fig. 3) to actuate the 10^0 cycle of the Multiplier Unit. At the conclusion of a cycle of the Multiplier Unit under control of one of the key denominations, a positive potential signal is impressed on terminal 292 (see Figs. 3 and 4), which fires the II stage tube 252 (Fig. 5), resulting in the extinguishment of the I tube 251, its anode dropping in potential as capacitor 293 of the II tube cathode is charging, while at the same time the capacitor 274 is discharging. The firing of the II tube 251 also causes a rise in potential on terminals 191 and 294, priming tubes 181, 184, and 187 (Fig. 4) of the Denominational Distributor and causing the commencement of a cycle of operation of the Multiplier Unit under control of the 10^1 denominational keys. At the conclusion of this 10^1 multiplier cycle, terminal 292 (Figs. 3 and 5) receives another potential impulse, which causes the firing of the III Stage Control Tube 253 (Fig. 5), the extinguishment of the II Stage Control Tube 252, the priming of the III terminal 192 affecting tubes 182, 185, and 188 (Fig. 4) of the Denominational Distributor, and causing a positive potential rise on terminal 295 (Figs. 5 and 3) to commence a cycle of operation of the Multiplier Unit under control of the 10^2 denominational keys. At the conclusion of the 10^2 cycle of the Multiplier Unit of Fig. 3, an impulse is impressed on terminal 292 without result, as there are no more stage tubes to fire. At this point, the multiplication operation is complete, and the Start Key may be opened and the key switches of the Multiplier Unit and the Multiplicand Unit restored to unoperated condition. It is to be noted that the last impulse on terminal 292 may be used to control any type of automatic key restoring means, by providing a tube to fire after the III stage Control tube, which can operate, for instance, an electromagnet. Such key restoring means is not shown, as it is no part of the invention and is old in the calculating machine art.

The Multiplier Unit.

The Multiplier Unit is shown in Fig. 3 and comprises nine digit tubes "1," "2," "3," "4," "5," "6," "7," "8," and "9" and numbered 300, 301, 302, 303, 304, 305, 306, 307, and 308, a relay tube 309 for creating an impulse to cause a step of operation of the Stage Control Unit by route of terminal 292, two delay tubes 310 and 311, which time the delivery of the Multiplicand Unit recycling impulses to terminal 100, and three denominational banks of nine digit key switches representing the units, tens, and hundreds decimal denominations, for convenience referred to as 10^0, 10^1, and 10^2 denominations.

In a multiplying operation, the multiplier factor is set up by closing one key switch in each selected bank. The Multiplier Unit operation is by cycles, each key bank controlling the operation of the digit tubes during one of the cycles by determining where in the series of nine digit tubes the operation of a cycle commences, and consequently how many tubes will operate in that cycle. The digit tubes are connected to be operated serially one at a time toward the "9" tube, in response to impulses commonly received by the grids of all the tubes over conductor 320, which originate from the last transfer control tube 321 (Fig. 8) and impressed on terminal 175. Thus, after an entry of the multiplicand factor into the Accumulator, the transfer cycle takes place, and, at the conclusion of the transfer cycle, an impulse on terminal 175 causes a step of operation of the Multiplier Unit's tubes. Consequently, the number of tubes to operate in a particular denominational cycle of the Multiplier Unit determines the number of times the multiplicand factor is entered into the Accumulator, and into what denominations of the Accumulator it is entered is determined by the Denominational Distributor, which, with the Multiplier Unit, is jointly controlled by the Stage Control Unit to correlate the multiplying operation by the denomination of the Multiplier Unit in control.

If, for example, it is desired to multiply by five, the "5" key 322 in the 10^0 denomination is operated the "0" keys 340 and 341 in the 10^1 and 10^2 banks are operated, the multiplicand factor is set up (Fig. 2), and the Start key (Fig. 5) is closed. The Denominational Distributor tubes 180, and 186 (Fig. 4) become primed, and a positive potential impulse is given to terminal 291 (Figs. 5 and 3), which is conveyed through a rectifier 323 (Fig. 3) shunted by 500,000-ohm resistor 324, and through .01-microfarad capacitor 325, stage initiating conductor 299 and key switch 322 to point 326 in the grid circuit of "5" tube 304, temporarily relieving the normal controlling

bias, causing it to fire and become conducting. The cathode potential supply circuit of tube 304 has therein a 15,000-ohm resistance which causes it to rise suddenly in potential, and this is conveyed by conductor 327 and .001-microfarad capacitor 328 to a common multiplier output conductor 329, to point 330, and from there through .0002-microfarad capacitor 331 to fire delay tube 310, which in turn fires delay tube 311, which passes a cathode positive potential impulse on to terminal 100 to cycle the multiplicand unit and enter the multiplicand in the Accumulator under control of Stage I tubes of the Denominational Distributor. At the conclusion of the multiplicand entry, the transfer cycle takes place in the Accumulator, and at the conclusion of the transfer cycle an impulse is impressed on terminal 175 (Figs. 8 and 3), which impulse is impressed through individual capacitors, like .00005-microfarad capacitor 332, onto the grid circuits of all the nine digit tubes of the Multiplier Unit. Each of such tubes' grids has a normal controlling bias which is primed to near the firing point if the digit tube of next lower value is conducting, and hence such priming causes the positive potential on conductor 320 to fire the "6" tube 305 to the exclusion of any other of the Multiplier Unit digit tubes. This causes a positive potential impulse on conductor 329, which causes a cycle of the Multiplicand Unit and in addition causes a rise on all the digit tube cathodes, because all are coupled to conductor 329. The cathode of the conducting "5" tube is within fifteen volts of the anode potential, and the additional rise caused by the firing of the "6" tube causes a cessation of current flow in the "5" tube, and it is extinguished. This operation continues, the "7," "8," and "9" tubes firing in succession, giving a total of five cycles of Multiplicand operation, which corresponds to the value of the operated "5" key 322. The condition of conduction in the "9" tube 308 primes the relay tube 309 by a portion of the cathode rise being conveyed by point 333, resistor 334, point 335, resistor 336, and conductor 337 to the grid circuit of tube 309. The grid of tube 309 is also connected by a .00005-microfarad capacitor 338 to conductor 320, and, upon receipt of an impulse on terminal 175 while "9" tube 308 is conducting, the relay tube 309 will fire, extinguishing the "9" tube and passing a positive potential impulse originating at its cathode, over conductor 339 to terminal 292 (see Fig. 5) to cause the firing of the II Stage Control tube 252 (Fig. 5) and the extinguishment of the I Stage Control tube 251. An impulse is consequently impressed on terminal 294 (Figs. 3 and 5), which is conveyed through the operated "0" key switch 340 and conveyed through point 335, resistor 336, and conductor 337 to fire the relay tube 309. As a consequence, no action occurs in the Multiplicand Unit, and the Stage Control Unit is actuated to cause the III Stage tube 253 (Fig. 5) to fire. This impresses an impulse on terminal 295 (Figs. 3 and 5), which, as "0" key switch 341 is closed, again immediately fires the relay tube 309, and the operation is over, and the multiplicand has been entered five times into the Accumulator. If, in the example just given, instead of the "0" key switch 341 in the 10^2 denomination of the Multiplier Unit having been operated, it was the "8" key 342 that was operated, then the last impulse received on terminal 295 would have fired the "2" tube 301, and, as a consequence, the Multitiplicand Unit would be actuated and the Multiplicand factor would be entered into the Accumulator under control of the Stage III tubes of the Denominational Distributor. Such multiplicand entry would be made as each of the tubes "2," "3," "4," "5," "6," "7," "8," and "9" of the Multiplier Unit fired in succession, and then the relay tube 309 would fire, ending the operation. Relay tube 309 is arranged in a circuit so that it self-extinguishes after it is rendered conducting.

Tube 310, when conducting, is thereafter extinguished by the firing of tube 311, and the tube 311 is self-extinguishing, as will be apparent as the circuits and circuit elements of Fig. 3 are specified.

All of the anodes of tubes "1" to "9" inclusive are supplied with 115 volts positive potential by being connected to conductor 350, which is connected through 3,500-ohm resistor 351, point 352, 500-ohm resistor 353, point 354, and 250-ohm resistor 355 to 115-volt positive source of potential 356. The anode of tube 309 receives potential from point 352, and point 354 is coupled to ground through .5-microfarad stabilizing capacitor 357. The cathode of each digit tube is connected to ground on one side through a 15,000-ohm resistor, like resistor 358 associated with the "4" tube, and is connected to negative 150-volt supply conductor 359, through a 100,000-ohm resistor 360, a point like point 361, and a 100,000 resistor-ohm resistor, like resistor 362. This gives each cathode a normal potential of 10 volts negative, which rises to 80 volts positive when the tube is conducting. Points like point 361 supply the grid bias for the succeeding tube, and

normally it is 80 volts negative and rises to 35 volts negative when the associated tube is conducting. Points like point 361 are connected to the succeeding tube's grid through a 250,000-ohm resistor, like resistor 363, a point like point 326, a 250,000-ohm resistor like resistor 364, a point like point 365, and a 50,000-ohm resistor like resistor 366. Tube 309, which originates the impulses which operate the Stage Control Unit, receives its anode potential from point 352. Its cathode is connected to ground through 50,000-ohm resistor 367 in parallel with a .0005-microfarad capacitor 368, and to the negative potential supply conductor 359 through 650,000-ohm resistor 369. The grid of tube 309 receives its potential through 50,000-ohm resistor 336 and 250,000-ohm resistor 334 from the point 333 in the negative leg of the cathode supply circuit of the "9" tube. With the circuit values just given, the tube 309 will self-extinguish when rendered conducting, and in firing sends an impulse over conductor 339. The before-mentioned delay tubes 310 and 311 are arranged to fire in succession on the firing of any one of the digit tubes "1" to "9," the firing of tube 311 giving rise to a positive potential impulse at terminal 100 to operate the impulse generator. The purpose of the consequent delay is to permit the stabilization of the potentials in the Stage Control and Denominational Distributor Units after a denominational shift. The anode of tube 310 receives its potential through 3,500-ohm resistor 371, 500-ohm resistor 372, point 373, and 250-ohm resistor 374, which is connected to a 115-volt positive supply terminal. Point 373 is coupled to ground by means of .5-microfarad capacitor 3750. The cathode of tube 310 is connected on one side to ground through 15,000-ohm resistor 375 in parallel with .001-microfarad capacitor 376, and on the other side through 150,000-ohm resistor 377, point 378, 300,000-ohm resistor 379, and point 380 to a negative 150-volt source of potential 387. The grid of tube 310 receives its normal controlling bias through 50,000-ohm resistor 381, point 382, 500,000-ohm resistor 383, and point 384, which is connected on one side through 50,000-ohm resistor 385 to ground, and through 250,000-ohm resistor 386 on the other side to point 380, which leads to the 150-volt negative terminal 387. When tube 310 is fired by receipt of an impulse through capacitor 331, its cathode rise in potential is impressed through resistor 377, point 378, and 500,000-ohm resistor 388 to the grid of tube 311, after the charging of .001-microfarad delay capacitor 389, which couples point 390 to ground. The anode supply for tube 311 is taken from point 391, and the cathode is coupled to ground through 50,000-ohm resistor 392 in parallel with .002-microfarad capacitor 393. As tube 311 fires, tube 310 is extinguished due to the drop in potential of its anode, and tube 311 passes on an impulse to the impulse generator over terminal 100 and then self-extinguishes.

THE ACCUMULATOR.

Six denominational banks are provided in the Accumulator. The units or 10^0 bank and the tens or 10^1 bank are shown in Fig. 6, the hundreds or 10^2 bank and the thousands or 10^3 bank are shown in Fig. 7, and the tens of thousands or 10^4 bank and the hundreds of thousands or 10^5 bank are shown in Fig. 8.

There are ten digit tubes in each bank, but those tubes representing the digits 8, 7, 6, 5, 4 and 3 in each bank are omitted in the drawings, as shown by dotted lines 400 in Fig. 6, for instance, such omission being only of a repeating network pattern of tubes and circuits which are fully shown in connection with the remaining tubes of each bank. It will be understood that the number tubes in a bank can be increased or decreased to make it of any size, so as to serve other than decimal numerical notation. Associated with each denominational bank are a transfer tube "T" and a Transfer Control tube "TC" for accomplishing denominational transfers of carry-over data.

The units bank 10^0, being typical, will be described as representative of all the banks as regards the ring of digit tubes. Anode voltage of 115 volts positive is supplied from terminal source 401 through 250-ohm resistor 402, point 403, and 7,500-ohm resistor 404 and conductor 405, to which all the anodes are directly connected. The cathode of each tube is connected to ground through a 15,000-ohm resistor like resistor 406 in parallel with a .002 microfarad capacitor like capacitor 407, and is also connected to negative supply conductor 408, supplied with 150 volts negative, through a 100,000-ohm resistor like resistor 409, a point like point 410, and a 100,000-ohm resistor like resistor 411. Points like point 410 are connected to the grid of the succeeding tube in the ring through a 500,000-ohm resistor like resistor 412, a point like point 413, and a 50,000-ohm resistor like resistor 414. Points like point 413 are each coupled to a common input conductor 417 for the denomination through a .00002-microfarad capacitor like capacitor 415. A switch like switch 416 is provided between ground and the grid of each "0"

tube, so that, upon temporary closing of the switch, the "0" tube will fire and become conducting. As a tube becomes conducting, it primes the grid of the next succeeding tube of the ring, as a conducting tube's cathode rises in potential. This relieved bias on the succeeding tube makes it more susceptible to a positive input impulse on conductor 417 than any other tube of the ring. Circuit values given for the Denominational Distributor relay tubes will cause the output from them in the form of impulses to fire a primed tube of the Accumulator but not an unprimed one. Conductor 420 closes the denominational ring by connecting the "0" tube cathode priming point 421 to the "1" tube's priming point 422. The anode supply conductor will temporarily drop in potential as the cathode-ground capacitor of a firing tube charges, while the cathode of the preceding priming tube's cathode-ground capacitor is discharging. This causes a temporary cessation of anode-cathode potential in the preceding tube, extinguishing it. Thus a number of impulses impressed on output conductor 417 will cause the same number of tubes to fire successively in the ring, and the conducting tube represents the accumulated data. The data is read by observing the flow in the tubes or by sensing their condition electro-mechanically.

It is arranged to have a transfer tube 423 fire each time the "0" tube fires, indicating one full cycle of operation of the ring, such transfer tube later being extinguished to create an impulse to cause a step of operation in the ring of next higher denomination. Switches like switch 418 in the anode supply of each "T" tube are opened before the zeroizing switches are closed to prevent the "T" tubes from firing. After zeroizing all of the Accumulator, the switches, like switch 418, are closed.

Input conductor 417 receives impulses from terminal 170, which is the 10^0 output from the Denominational Distributor (Fig. 4).

Transfer tube 423 receives its anode potential from 135-volt positive terminal 425, through switch 418, 250-ohm resistor 426, point 427, and 7,500-ohm resistor 428. Point 427 is coupled to ground by .1-microfarad capacitor 429. Tube 423 receives its cathode potential by being connected through 10,000-ohm resistor 430 to ground. The grid of tube 423 receives its potential by being connected through 50,000-ohm resistor 431, point 432, and 500,000-ohm resistor 433 to point 434, which is connected through 50,000-ohm resistor 435 to ground on one side, and through 250,000-ohm resistor 436 to the negative 150-volt conductor 408 on the other side. The transfer tube is thus ordinarily non-conducting but is rendered conducting by a positive impulse originating at the cathode of the "0" tube 437 when the "0" tube fires, said impulse being impressed through .00005-microfarad capacitor 438 onto grid bias point 432.

At the initiation of the transfer cycle caused by a positive potential impulse received on terminal 148 leading to the grid of the Transfer Control tube 439, tube 439 is fired, and, upon becoming conducting, its cathode rises in potential, which rise is transmitted through .01-microfarad capacitor 440 and impressed on the cathode of transfer tube 423. If tube 423 is conducting, it is by that impulse from tube 439 extinguished, and its anode rises suddenly in potential, passing on said positive impulse through .0005-microfarad capacitor 441 and through rectifier 442 oriented to pass positive impulses to the input conductor for the next higher denominational bank. Rectifier 442 is shunted by 50,000-ohm resistor 443. Thus, if the denominational ring of 10^0 bank has, during one cycle of the impulse generator, passed through zero, transfer tube 423 will have fired, and later, at the conclusion of the cycle of the impulse generator, transfer control tube 439 will fire and extinguish tube 423, passing on the transfer impulse to the next higher order, causing the addition therein of one unit. Transfer Control tube 439 obtains its anode potential from 115-volt positive source 445, through 250-ohm resistor 446, point 447, and 4,000-ohm resistor 448. Point 447 is coupled to ground through .1-microfarad capacitor 449. The cathode of tube 439 obtains its potential by being connected to ground through 15,000-ohm resistor 4490 in parallel with .01-microfarad capacitor 450, and to negative 150-volt source 451 through 150,000-ohm resistor 452, point 453, and 300,000-ohm resistor 454. Point 453 is coupled to ground by .002-microfarad delay capacitor 455. The grid of tube 439 obtains its normal bias through 50,000-ohm resistor 456, point 457, and 500,000-ohm resistor 458, which is connected to point 459, grounded on one side through 50,000-ohm resistor 460 and on the other side connected through 250,000-ohm resistor 461 to negative supply terminal 451. Point 457 is connected to terminal 148 through .00005-microfarad capacitor 462. With the circuit elements as given, transfer control tube 439 fires on receipt of a positive impulse on terminal 148 and is immediately self-extinguished, meanwhile having issued a

positive impulse through capacitor 440 to extinguish the transfer tube, if it was conducting, and causing the transfer unit to be added in the next higher denomination. The rise in potential of point 453, as tube 439 fires, is conveyed, after the charge of capacitor 455, to the grid of the 10^1 bank's Transfer Control tube 470, to fire it. Point 453 is the grid bias point for tube 470. Tube 470 is supplied with the same potentials and circuits as is tube 439 and, on being fired, extinguishes the transfer tube for the 10^1 bank if conducting passing on an impulse to the input conductor of the 10^2 bank by way of terminal 471 (see also Fig. 7). The firing of Transfer Control tube 470 for the 10^1 denominational bank also passes on an impulse over terminal 472 to fire the Transfer Control tube for the 10^2 denominational bank. Input conductor 473 of the 10^1 denominational bank contains a rectifier 474 to pass positive potentials only in the direction of the arrow to prevent absorption of positive impulses by the circuits of the Denominational Distributor originating when the transfer tube of next lower denomination is extinguished. Such a rectifier is provided in each order except the lowest. Each rectifier such as rectifier 474 is shunted by a 50,000-ohm resistor such as resistor 475. Transfer tube output from the 10^3 denomination (Fig. 7) is over terminal 476 (see Fig. 8), and output from the Transfer Control tube of the 10^3 denomination is over terminal 477.

The 10^5 denominational bank (Fig. 8), being for overflow purposes only, receiving impulses only from the 10^4 denominational bank through point 493 and rectifier 501, has appended to its input circuit capacitor 502 of .0005 microfarad, resistor 503 of 50,000 ohms, rectifier 504, and resistor 505 of 50,000 ohms to simulate the circuit elements appended to the lower denominational banks by reason of their connection to the Denominational Distributor Unit.

Transfer tube 510 is provided to show how additional overflow denominational banks may be added to the Accumulator or how a signal may be made indicating a full Accumulator.

The output from the transfer tube of the 10^5 denominational order is shown by dotted line 490 (Fig. 8) to indicate how transfers may be made to higher orders.

Transfer tube 510 is arranged in a self-extinguishing circuit, receiving 75 volts positive anode potential from source 511, through resistor 512 of 250 ohms, point 513, and resistor 514 of 500 ohms. Point 513 is coupled to ground through capacitor 515 of .1 microfarad. The cathode is connected to ground through 50,000-ohm resistor 516 in parallel with .0005-microfarad capacitor 517.

The positive impulse output of the Transfer Control tube 321 of the last order is conveyed over terminal 175 to step the multiplier unit (Fig. 3) a step, as has been explained.

When the 10^5 denomination passes through zero, a signal appears on conductor 490, which may be used for signalling an overflow of data.

The circuit elements of the Accumulator have been chosen to give it an impulse acceptance rate at approximately twice the rate of production thereof by the Impulse Generator.

Operation.

Referring to Fig. 1, the operation of the multiplying device will be summarized.

The Accumulator is zeroized by operation of the zeroizing keys in all orders of the Accumulator after removing anode potential temporarily from the Transfer tubes. As an example problem, the multiplicand factor chosen will be 658, and the multiplier factor chosen will be 123. These factors are set up on the associated keys and the Start key is closed (Fig. 5), which fires the Start tube. After a short delay, the "I" Stage Control tube is fired, priming Column I of the Denominational Distributor tubes and sending an impulse to the 10^0 input of the Multiplier Unit (Fig. 3), which is routed through the "3" key switch to fire the "7" tube of the Multiplier Unit. The firing of the "7" tube fires the two Delay tubes in series, and the last to fire sends an impulse over terminal 100 (see also Fig. 2) to the Multiplicand Unit to fire the nine digit tubes in succession. This act sends out eight impulses on terminal 160, five impulses on terminal 161, and six impulses on terminal 162 (see Fig. 4) to the Denominational Distributor, causing the relaying of eight impulses to the 10^0 bank of the Accumulator over terminal 170 (see Fig. 6), five impulses over terminal 171, and six impulses over terminal 172 (see Fig. 7), actuating the Accumulator accordingly. The Transfer Indicator tube (Fig. 2) is then fired, which sends an impulse over terminal 148 (see Fig. 6) to fire the Transfer Control tube of the 10^0 bank of the Accumulator. The Transfer Control tubes are fired serially, and the associated transfer tubes, if any are conducting, will be extinguished serially thereby. It will be apparent that, after this first entry, none will be conducting. The Transfer Control tube of the 10^5 denomination of the Accumulator (Fig. 8) passes on an impulse over terminal 175

(see also Fig. 3), which fires the primed "8" tube of the Multiplier Unit, and, after the two delay tubes have fired, an impulse is sent over terminal 100 (see also Fig. 2) to cause another cycle of operation of the Impulse Generator to enter the number 658 into the Accumulator, as before described. As yet, no transfer having taken place, the number 206 stands in the Accumulator. As the 10^0 and 10^2 denominational rings of the Accumulator have passed through zero, and the 10^2 ring stands on zero, the Transfer tubes of the 10^0, 10^1 and 10^2 denominational rings of the Accumulator are conducting. As the Transfer Control tubes are serially operated, first the 10^0 Transfer tube is extinguished, entering one unit into the 10^1 denomination, making the Accumulator read 216. Secondly, Transfer Control tube 10^1 fires, the 10^1 Transfer tube is extinguished, sending a unit to the 10^2 denominational ring, making the Accumulator read 316. Lastly, the 10^2 Transfer Control tube is fired, extinguishing the 10^2 transfer tube, sending a unit to the 10^3 denominational ring, making the Accumulator read 1316, which is the sum of 658 plus 658. The number 658 is entered once more in Stage I by reason of the firing of the "9" tube of the Multiplier Unit, and the Accumulator after the transfer then reads 1974. The end of the transfer tube cycle again sends an impulse over terminal 175 to the Multiplier Unit, but this time the Stage Control Shift tube 309 (Fig. 3) fires and sends an impulse over terminal 292 (see also Fig. 5), which fires the Stage II tube 252, extinguishing the Stage I tube, priming the Stage II column of the Denominational Distributor Unit, and delivering an impulse to terminal 294 (Fig. 3), serving the 10^1 bank of keys of the Multiplier Unit. As key "2" has been operated therein, the "8" tube will accordingly fire, firing the delay tubes and thereafter actuating the multiplicand unit to send out the same pattern of impulses, representing "658," to the Denominational Distributor. At this time, the Stage II column of tubes of the Denominational Distributor are primed, and the impulses are accordingly routed to the 10^1, 10^2 and 10^3 denominations of the Accumulator. After the Stage II entries have been made twice, the Stage Control Unit shifts to Stage III, wherein the 10^2, 10^3, and 10^4 denominations of the Accumulator are actuated, the entry of the multiplicand factor being made but once, as the 10^2 digit of the multiplier factor is 1. The multiplying operation is now complete. The final firing of the Stage Control shift tube 309 (Fig. 3) has no effect on the Stage Control tubes of Fig. 5, as III tube 253 primes no other tube. The Start key may now be opened, and all of the tubes except those in the Accumulator representing the product data will be in extinguished condition. The device is now ready for another multiplying operation, which may be performed with or without returning the Accumulator to zero.

It is apparent that the key switches of the Multiplier and Multiplicand Units may be controlled in any manner by record material according to well-known practices for the automatic setting up of factors.

The disclosed device is not to be deemed limited to the exact tubes, circuit elements, and time constants specified, as they are but illustrative of one embodiment of the invention.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. An electronic multiplying apparatus including a multi-denominational totalizer with transfer means between the denominational elements thereof, a cyclically operating impulse generator having associated therewith multiplicand selecting devices which are selectively operable in accordance with the digital values of the orders of the multiplicand to direct impulses relative to said values simultaneously into selected elements of the totalizer during each cycle of the generator, means operable after the completion of a cycle of the generator for initiating a transfer cycle through all elements of the totalizer, and means responsive to the conclusion of a transfer cycle for automatically initiating a further entry cycle of the impulse generator.

2. An electronic multiplying apparatus including a multi-denominational totalizer having transfer means between the denominational elements thereof, a single cyclically operating impulse generator, multiplicand selecting means which is selectively operable to direct specific numbers of impulses, in accordance with the relative digital values of the orders of the multiplicand, simultaneously into selected elements of the totalizer during each impulse cycle, a multiplier unit for determining the number of cycles to be executed by the impulse generator in accordance with the value of a multiplier, means operable at the conclusion of each impulse cycle for effecting a transfer cycle through all the elements of the totalizer, and means operable in response to the conclusion of each transfer cycle to cause the multiplier unit automatically to

bring about a further cycle of the impulse generator.

3. An electronic multiplying apparatus in which an impulse generator is caused to be operated in a succession of impulse generating cycles, the number of which is in accordance with the value of a multiplier, under the control of a multiplier unit, and at each cycle to transmit impulses significant of the values of all digits of the multiplicand, simultaneously to respective selected denominational elements of a multi-denominational totalizer having, between the elements thereof, transfer means which are adapted to be potentialised during entry operations subsequently to effect transfers, and in which entry operations are adapted to be suspended at the end of each entry cycle until the transfer of all digits by potentialised transfer elements has been effected, after which the multiplier unit is caused to effect a further cycle of the impulse generator in response to the completion of the transfer.

4. An electronic multiplying apparatus including a cyclically operating impulse generator, a multi-denominational totalizer adapted to receive trains of impulses from the generator significant of the value of a multiplicand, at each cycle of the generator, in several selected denominations thereof simultaneously, adjacent elements of the totalizer having transfer means therebetween which are adapted to be potentialised for subsequently effecting transfers into the element of the next higher order when an element of the lower order passes through zero, and transfer control means operable at the completion of each cycle of the impulse generator to cause potentialised transfer means to effect the transfer of units seriatim between the elements from the lowest to the highest orders therof, and also to initiate a further cycle of the impulse generator when the cycle of transfer operations has been completed.

5. An electronic multiplying apparatus in which a product is obtained as a result of repeated entries, each relative to a multiplicand, into a multi-denominational totalizer having transfer means between the denominational elements thereof, and including a cyclically operating impulse generator for transmitting impulses significant of the value of a multiplicand to selected elements of the totalizer simultaneously at each entry cycle, means operable after each entry cycle to effect a transfer cycle through all elements of the totalizer, a multiplier unit controlling the number of entry cycles to be performed by the impulse generator in respect of each denomination of the multiplier and operable in response to the completion of each transfer cycle to initiate a further entry cycle of the impulse generator, and a control unit operable as entries in respect of each denomination of the multiplier are completed to cause the multiplier unit to control the next series of cycles of the impulse generator in accordance with the next higher denomination of the multiplier and also to operate a distributor unit whereby the impulses of the next said series are directed to the elements of the totalizer of the respective next higher orders to those in which the former entries were registered.

6. An apparatus according to any one of the preceding Claims in which said impulse generator has associated in common therewith a multiplicand unit comprising selecting means in respect of each multiplicand denomination for selectively determining the number of impulses that shall be transmitted to the respectively associated elements of the totalizer in accordance with the values in the various denominations of the multiplicand.

7. An apparatus according to Claim 6 in which said selecting means includes a bank of circuit-closing contact sets for each denomination of the multiplicand, each bank including a contact set representative of each digit in the denomination, the like contacts in each bank being connected together in common to a conductor over which impulses are adapted to be transmitted to an associated element of the totalizer, whereas the other contacts of the contact sets in the several banks having the same digital significance are connected together and to a point in the output circuit from the impulse generator from which series of impulses representative of said digital significance are adapted to be derived.

8. An apparatus according to any one of the preceding Claims in which a transfer initiating device is caused to be operative at the completion of each cycle of the data entering means to transmit an electric transfer initiating impulse to cause the transfer means to effect a transfer cycle whereby potentialised transfers are effected in succession from the lowest to the highest order element of the totalizer.

9. An apparatus according to Claim 8, in which the transfer initiating device consists of an electronic tube which is rendered conducting at the completion of each cycle of the data entering means, the said transfer initiating impulse being derived from a point in the circuit of the tube as a result of the setting up of conduction therein.

10. An apparatus according to Claim 9 in which the transfer is effected by an impulse of positive polarity derived from the cathode circuit of the transfer initiating tube as the cathode thereof is rendered more positive as a result of conduction therein.

11. An apparatus according to Claim 10 in which the transfer initiating tube is gas-filled and includes a resonant network in its cathode circuit whereby, on the tube becoming conducting, the potential of the cathode is caused to approach sufficiently near to the potential of the anode to cause the tube to extinguish.

12. An apparatus according to any one of the preceding Claims in which the transfer means consists of a potential operated device, whose state is changed upon change of applied potential, associated with each denominational element of the totalizer and which is caused to change from its normal state, subsequently to effect a transfer, when the associated element passes through zero, and which is caused to revert to its original state each time the data entering means completes a data entering cycle to generate a carry forward impulse to the element of the next higher order.

13. An apparatus according to Claim 12 in which each potential operated device comprises an electronic transfer tube having a control electrode which is normally biassed to prevent conduction in the tube but which is rendered sufficiently positive, with respect to the cathode potential, to permit conduction in the tube when the associated totalizer element passes through zero, and in which, in a transfer cycle, conducting transfer tubes are caused to be extinguished in succession from the lowest to the highest order of the totalizer and impulses derived as a result of the consequent rise in anode potentials are transmitted to the elements of the respective next higher orders to enter units therein.

14. An apparatus according to any one of the preceding Claims 4, or 8 to 13, in which a transfer control means consists of electronic tubes having control electrodes, a transfer control tube being associated with each transfer element or tube, the transfer initiating impulse from the data entering means initiating conduction in the control tubes seriatim in ascending order of denominations to cause the extinction of their respective transfer tubes, in conducting, to effect transfers.

15. An apparatus according to Claim 14 in which the transfer tubes are gas-filled and, if conducting, are extinguished as a result of the increase in cathode potential of the associated control tube, when it becomes conducting, being reflected to the cathode of the transfer tube to bring the latter to a potential value relative to that of the anode at which conduction cannot be maintained.

16. An apparatus according to Claim 14 in which the said control tubes are gas-filled and each has a network connected in circuit therewith whereby on the tube becoming conducting, the cathode rises sufficiently in potential automatically to cause the tube to extinguish, and also influences the control electrode of the succeeding control tube to render that tube conducting.

17. An apparatus according to any one of the preceding Claims in which a signal resulting from the completion of a transfer cycle is reverted either to cause the data entering means to execute a further cycle, or if the last entry cycle comprised the final entry in respect of a particular denomination of the multiplier, to initiate the entries relative to the next higher order of the multiplier and also to modify the selection of the connections between the data entering means and the totalizer so that the denominational entries in respect of the latter will be made into the elements of the totalizer of the respectively next higher orders to the previous entries.

18. An apparatus according to Claim 17, including a multiplier unit consisting of an impulse responsive device which is differentially adjustable to count the impulses reverted on the completion of transfer cycles and which, on the reception of an impulse, applies a signal to the data entering means to cause it to execute a further cycle, and, in respect of a last entry of a multiplier denomination, also bringing about the said modification of the connections between the data entering means and the totalizer.

19. An apparatus according to Claim 18 in which the multiplier unit includes a plurality of electronic tubes, a tube being provided in respect of each digit in the denominational orders of the multiplier, and selectively operable means for each denomination of the multiplier depending on the capacity of the apparatus, which are respectively operable to select a number of tubes corresponding to the value of the respective digits of the multiplier and wherein the tubes selected by the said selecting means are adapted to be operated seriatim in consequence of the terminations of the transfer cycles of the totalizer in respect of each of said digits of the multiplier, from the units to the higher orders thereof, each tube on operation causing the data entering means to effect a further entry cycle.

20. An apparatus according to Claim

19 in which the electronic tubes are gas-filled and have control electrodes and are so arranged that the setting up of conduction in a tube causes any other conducting tube to be extinguished and primes the tube next to be operated, and in which signals reverted from the totalizer at the termination of each transfer cycle cause the selected tubes to fire seriatim, and each tube on firing causes an impulse to be transmitted to the data entering means to cause it to recycle.

21. An apparatus according to Claim 20 in which the cathodes of the tubes are capacitatively connected to a common conductor which is coupled to the data entering means, so that an impulse of positive polarity is transmitted to the latter as each tube fires.

22. An apparatus according to Claim 21 in which the said impulsing circuit between the multiplier unit and the data entering means includes a delay circuit to delay the transmission of said impulse for a period sufficient to ensure the stabilisation of the totalizer elements after the previous operation.

23. An apparatus according to Claim 22 in which said delay circuit includes an electronic tube having a control electrode thereof including a capacitance to delay the rise in potential of the control electrode to a point at which the tube can conduct as a result of an impulse from the multiplier unit, and impulse of positive polarity being derived from the cathode circuit of the tube to effect the recycling of the data entering means.

24. An apparatus according to any one of the preceding Claims in which impulse entries from the impulse generator are directed into respective elements of the totalizer over circuits selected by a distributor unit under the control of a stage control unit, the latter being operable in stages as each series of additive entries in respect of each denomination of the multiplier is completed to cause the distributor unit to modify the selection of the circuits so that entries in respect of a next higher denomination of the multiplier are entered into the elements of the totalizer respectively of the next higher orders.

25. An apparatus according to Claim 24 in which the input circuits leading into the totalizer elements from the distributor unit include unidirectional current carrying devices poled towards the former to prevent potential changes occurring within said elements from being reverted to the distributor unit.

26. An apparatus according to Claim 24 in which the stage control unit consists of a plurality of electronic tubes, there being a tube in respect of each denomination of the multiplier, according to the capacity of the apparatus, the tubes being adapted to be rendered conducting seriatim in response to signals received from the multiplier unit as each denominational stage of the calculation is completed, thereby to control the distributor unit to cause the latter to bring about the selective modification of the input circuits to the totalizer.

27. An apparatus according to Claim 26 in which the stage control tubes are gas-filled tubes having control electrodes, and arranged so that conduction in one tube primes the tube next to be operated and so that the establishment of conduction in a tube extinguishes any other conducting tube, the tube associated with the first stage being fired to prepare the apparatus for operation and to control the distributor unit to associate the denominational connections from the data entering means with corresponding elements of the totalizer, the tubes associated with the succeeding stages being rendered conducting seriatim as the stages of calculation are completed thereby to control the distributor unit to bring about the successive association of the said output connections with the respective next higher order elements of the totalizer at each stage.

28. An apparatus according to Claims 19, 20 or 24, 26 or 27, in which the selecting means of the multiplier unit comprises a bank of circuit closing devices for each denomination of the multiplier, each bank including a circuit closing contact set in respect of each digit in the denomination, the like contacts of the contact sets in each denominational bank being commoned to a connection from the stage control unit, whereas the other contacts of contact sets having the same digital significance in the several banks are commoned together and to a connection over which the operation of the relevant electronic device of the multiplier unit is controlled, the stage control unit being adapted to apply a potential to the common connections of the banks of selecting devices seriatim as the entries in respect of each denominational stage of the calcution are effected, to cause the multiplier unit to control the data entering means in accordance with the denominational digits of the multiplier in ascending order.

29. An electronic calculating apparatus for obtaining products as a result of the repeated addition of a multiplicand fac-

tor in accordance with a multiplier factor, substantially as described with reference to the accompanying drawings.

Dated this 21st day of March, 1947.

E. T. BEAVIS,

Acting for the Applicants.

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FIG. 1

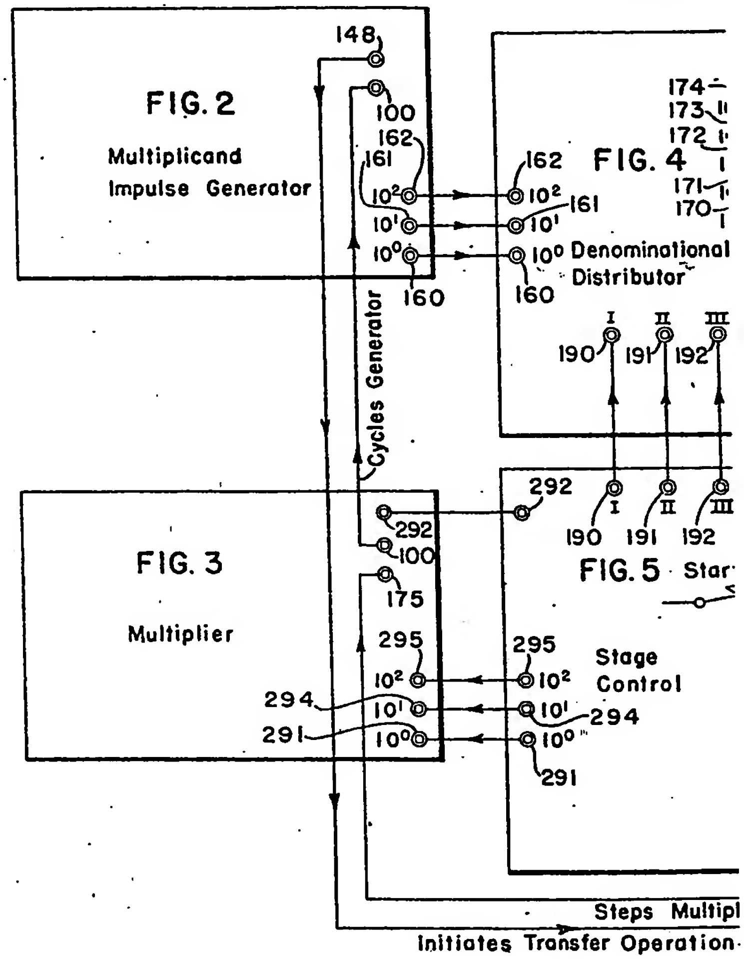


FIG. 2
Multiplicand Impulse Generator
148
100
162
161
10^2
10^1
10^0
160
FIG. 4
Denominational Distributor
174
173
172
171
170
I
II
III
190
191
192
Cycles Generator
FIG. 3
Multiplier
292
175
295
294
291
FIG. 5
Stage Control
Steps Multipl
Initiates Transfer Operation

FIG. 1

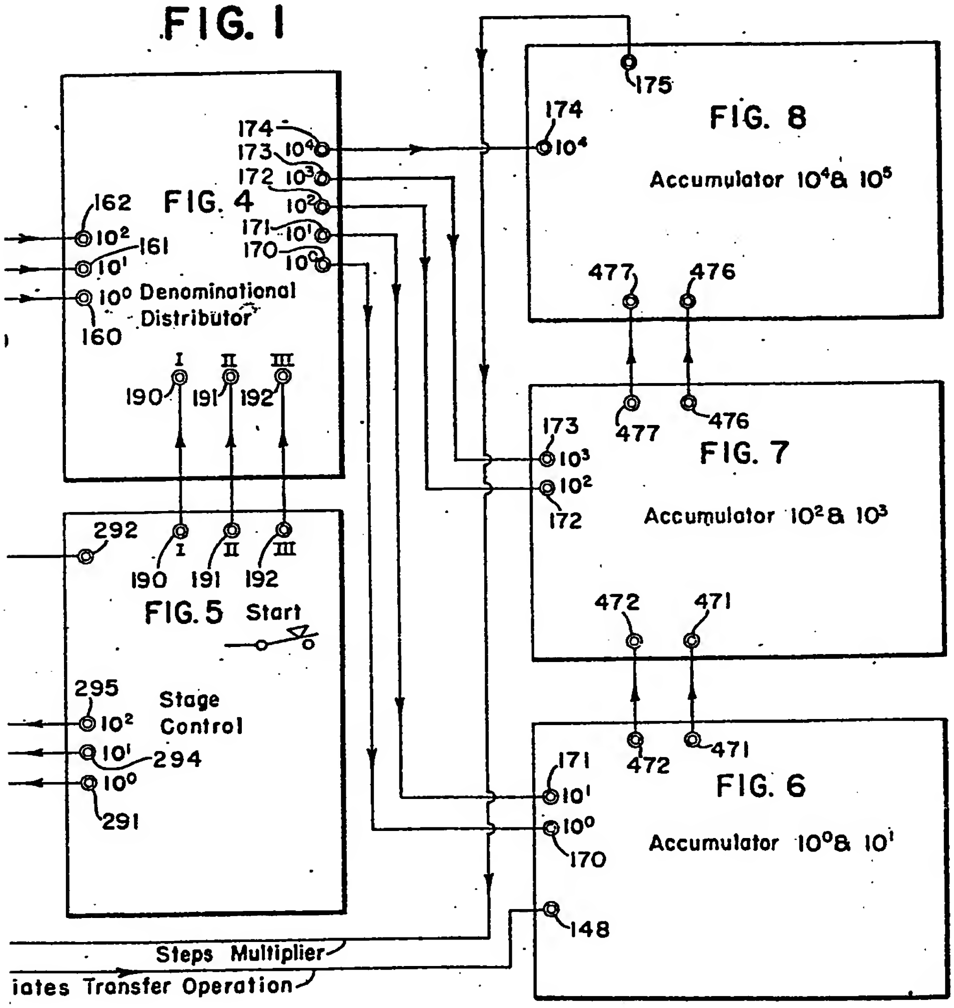
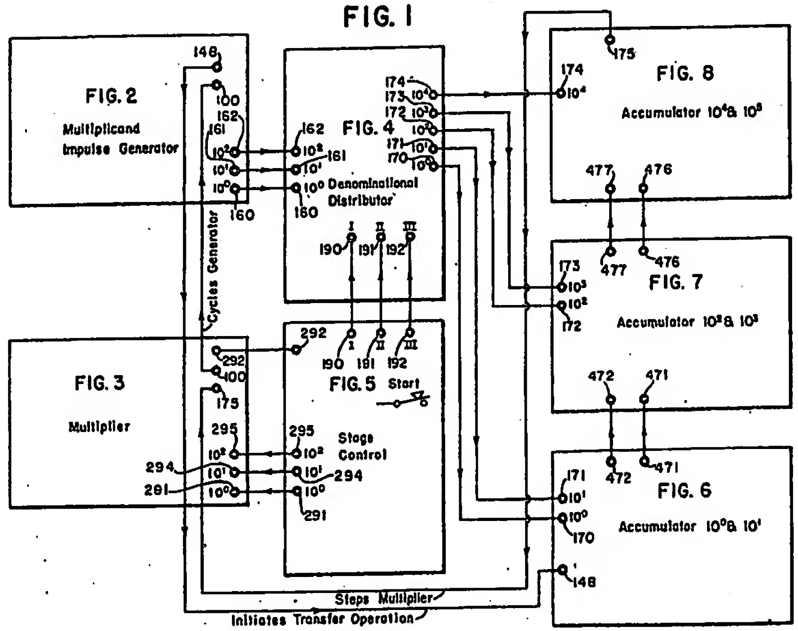


FIG. 4
Denominational Distributor
162
161
160
174
173
172
171
170
190
191
192
FIG. 5
Start
Stage Control
292
295
294
291
FIG. 8
Accumulator 10⁴ & 10⁵
175
477
476
FIG. 7
Accumulator 10² & 10³
472
471
FIG. 6
Accumulator 10⁰ & 10¹
148
Steps Multiplier
iates Transfer Operation

FIG. 1



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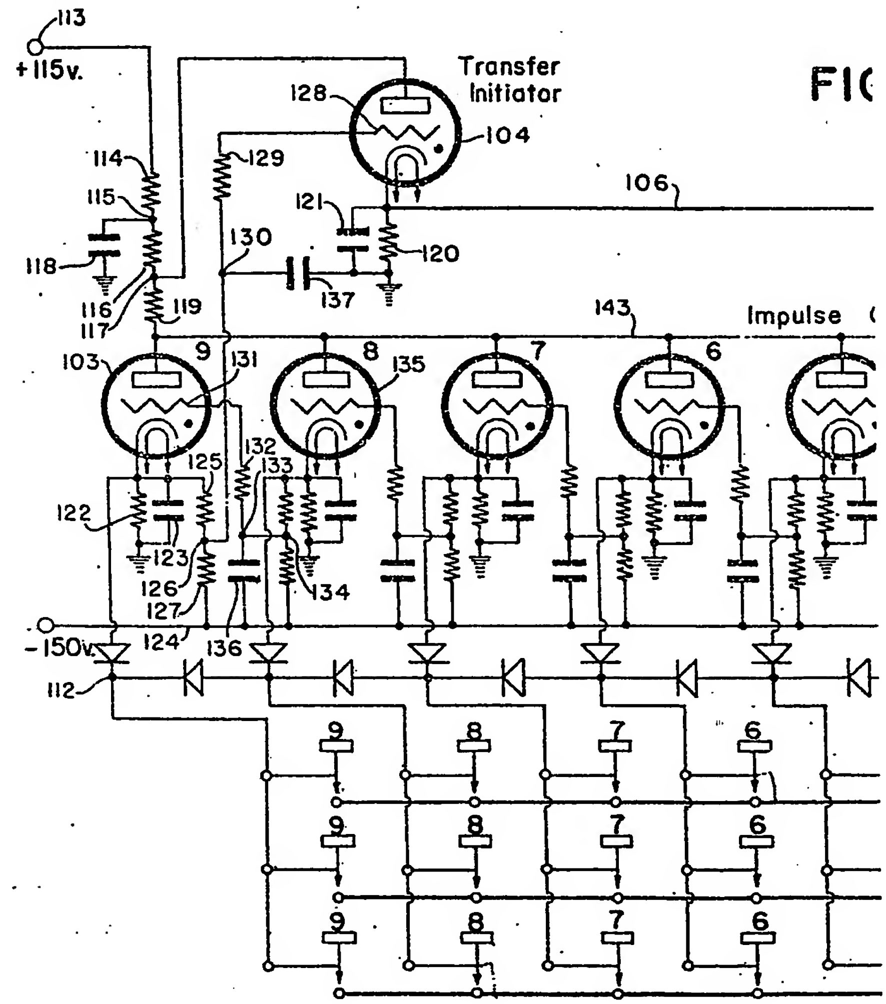
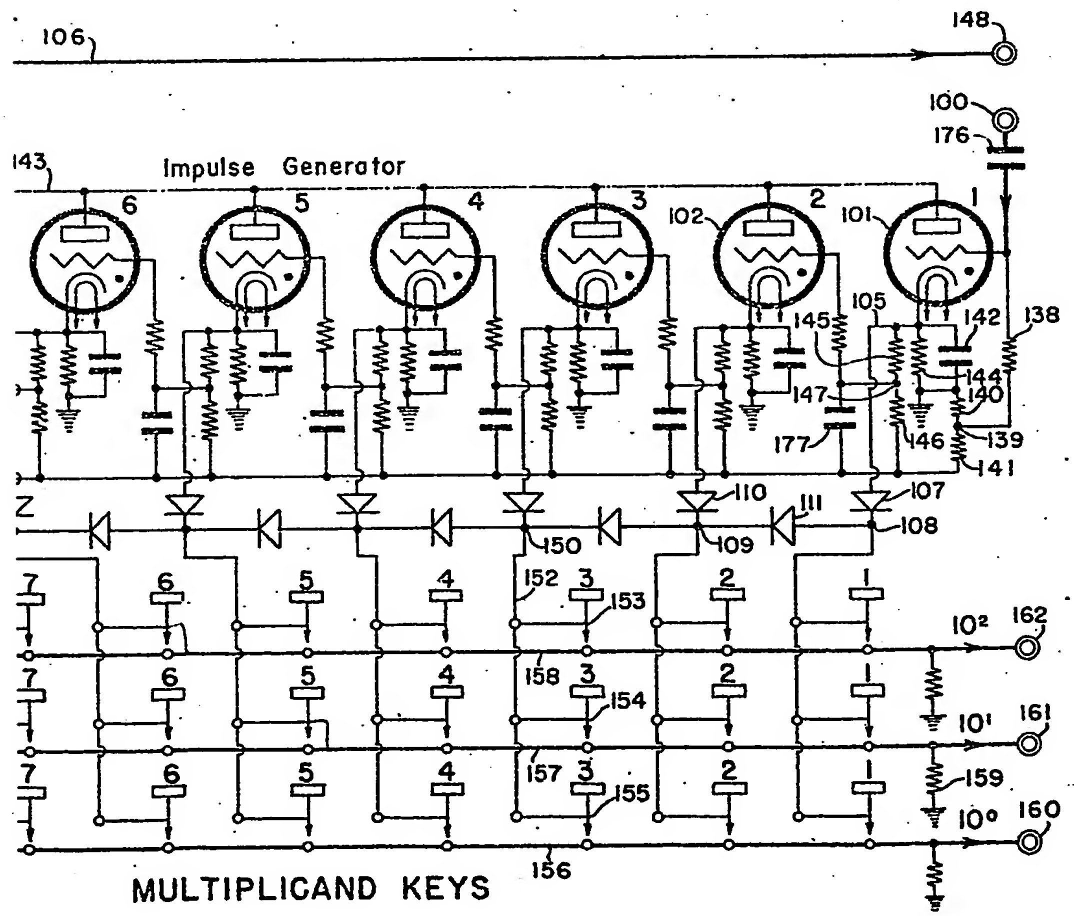


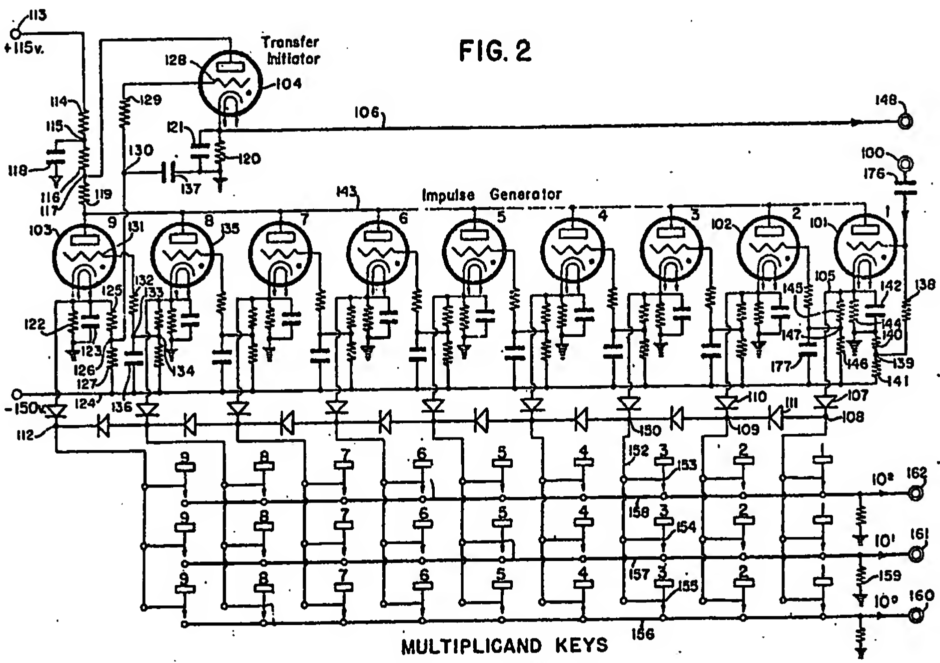
MULTIPLI

FIG. 2



MULTIPLICAND KEYS

FIG. 2



MULTIPLICAND KEYS

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FIG. 3

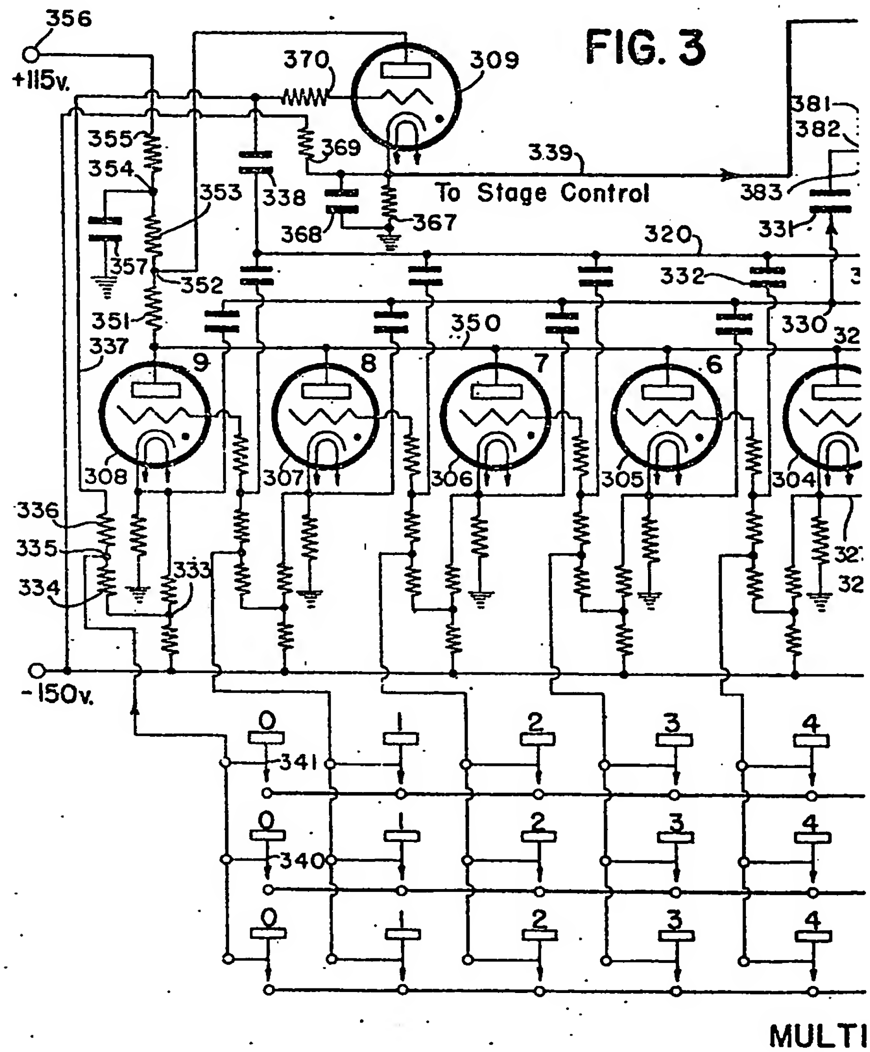
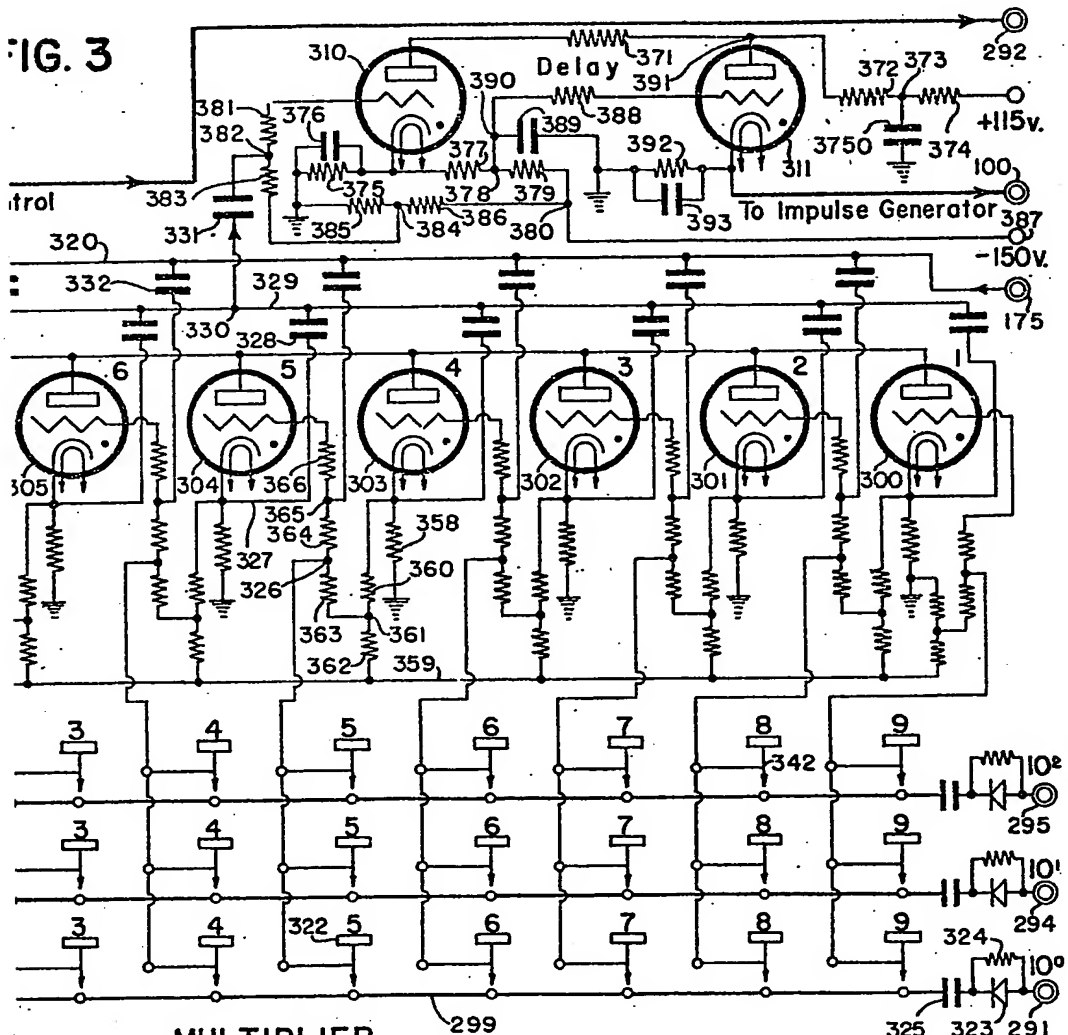
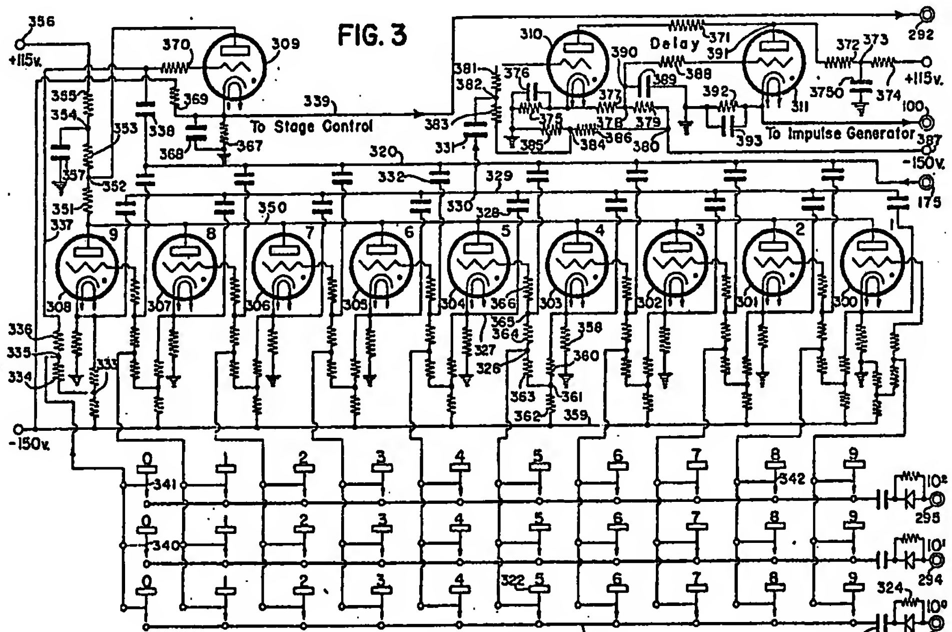


FIG. 3



MULTIPLIER

FIG. 3



MULTIPLIER

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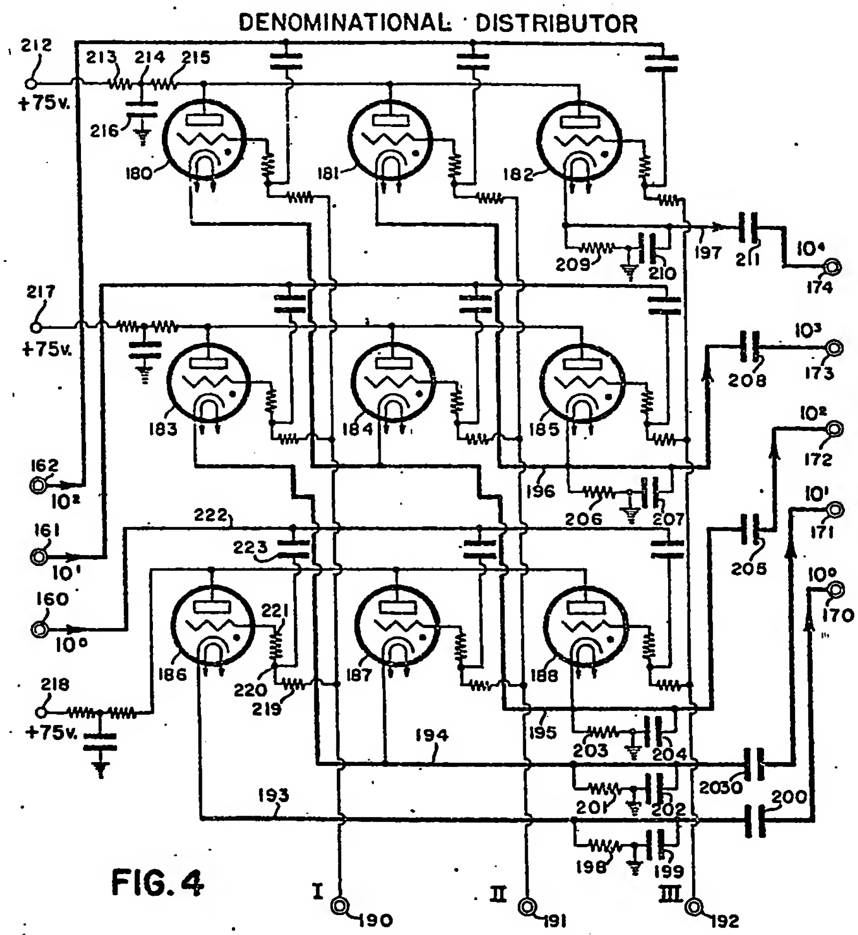
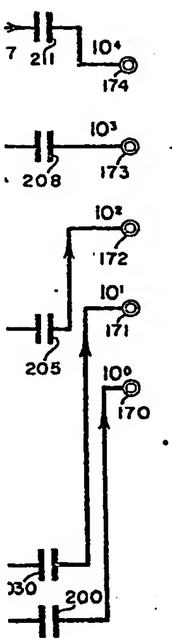
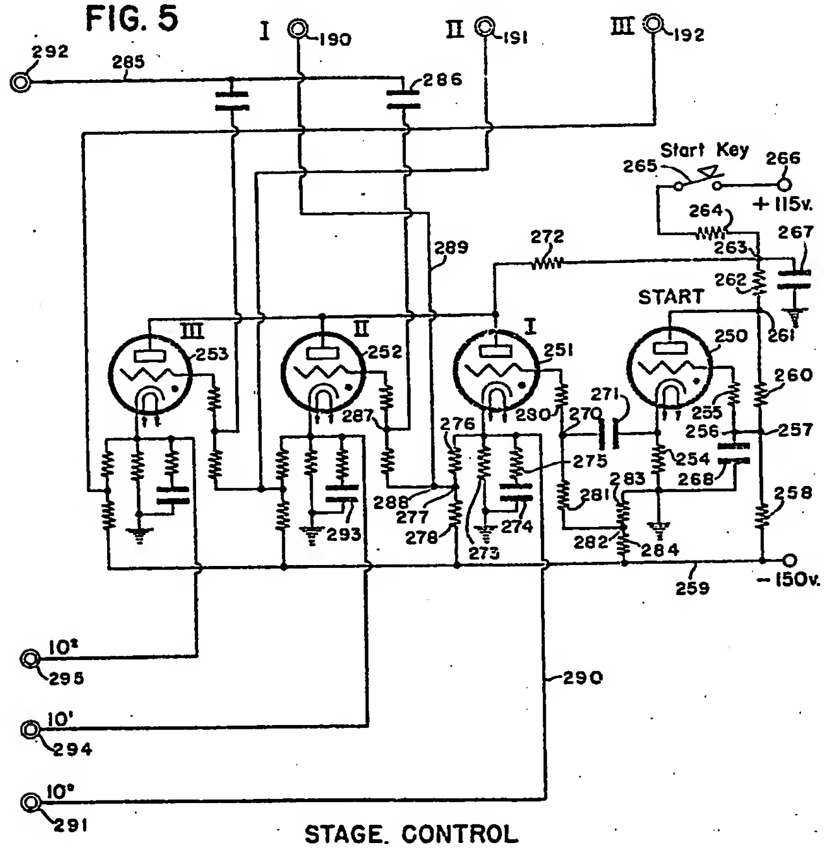

DENOMINATIONAL DISTRIBUTOR
212
+75v.
213
214
215
216
180
181
182
209
210
197
211
10⁴
174
217
+75v.
183
184
185
208
10³
173
10²
172
162
10²
196
206
207
161
10¹
222
223
205
10¹
171
160
10⁰
10⁰
170
186
221
220
219
187
188
218
+75v.
194
195
203
204
2030
193
201
202
200
198
199
I
190
II
191
III
192

FIG. 4



92

FIG. 5



STAGE. CONTROL

DENOMINATIONAL DISTRIBUTOR

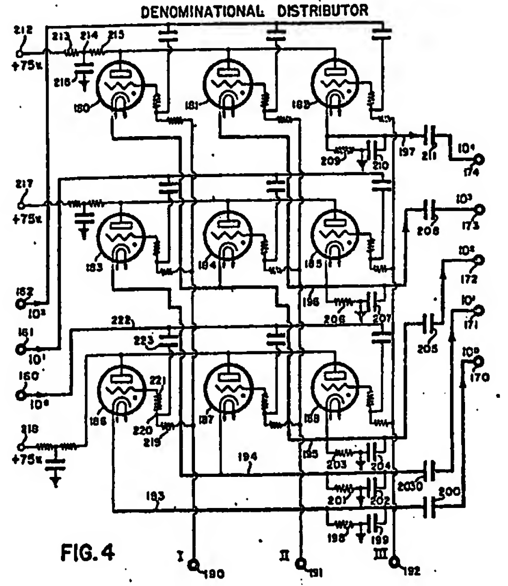
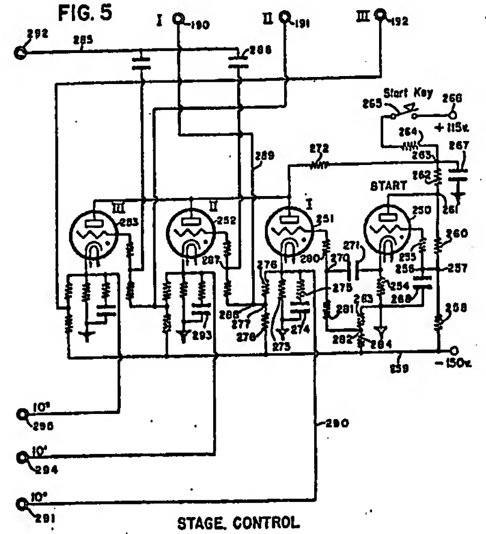


FIG. 4

FIG. 5



STAGE. CONTROL

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[This Drawing is a reproduction of the Original on a reduced scale.]

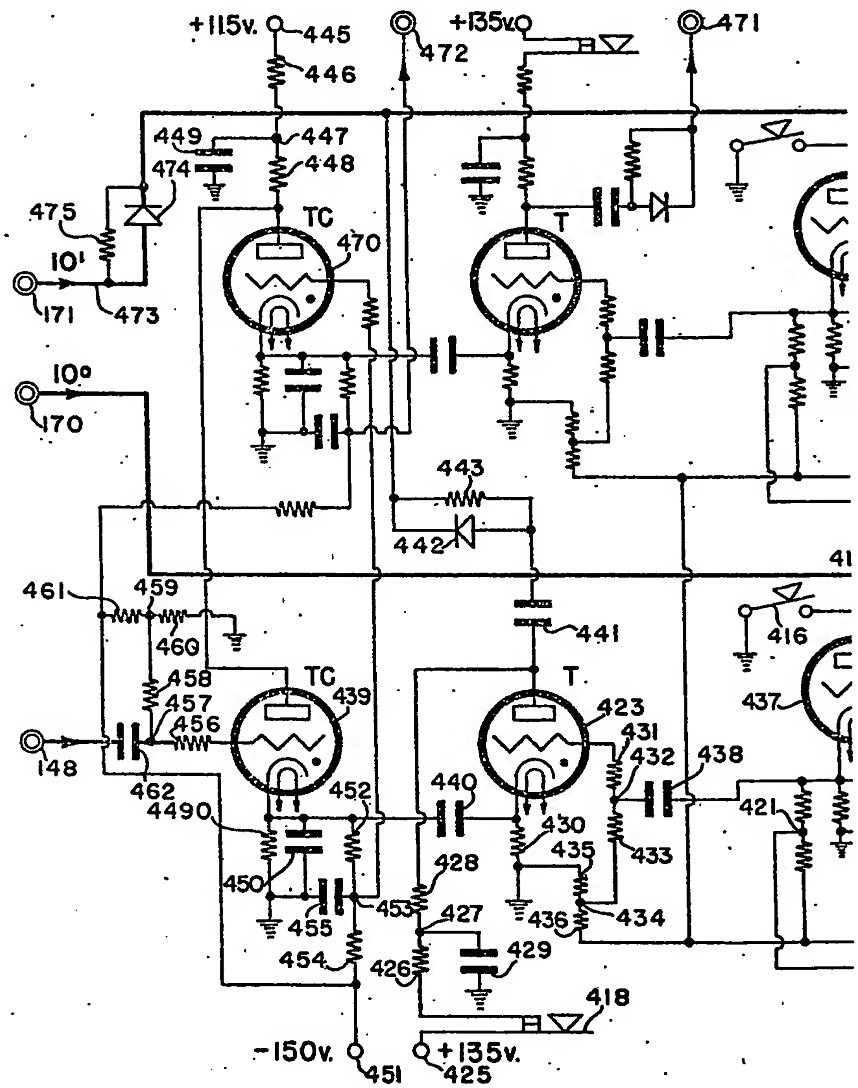


FIG. 6

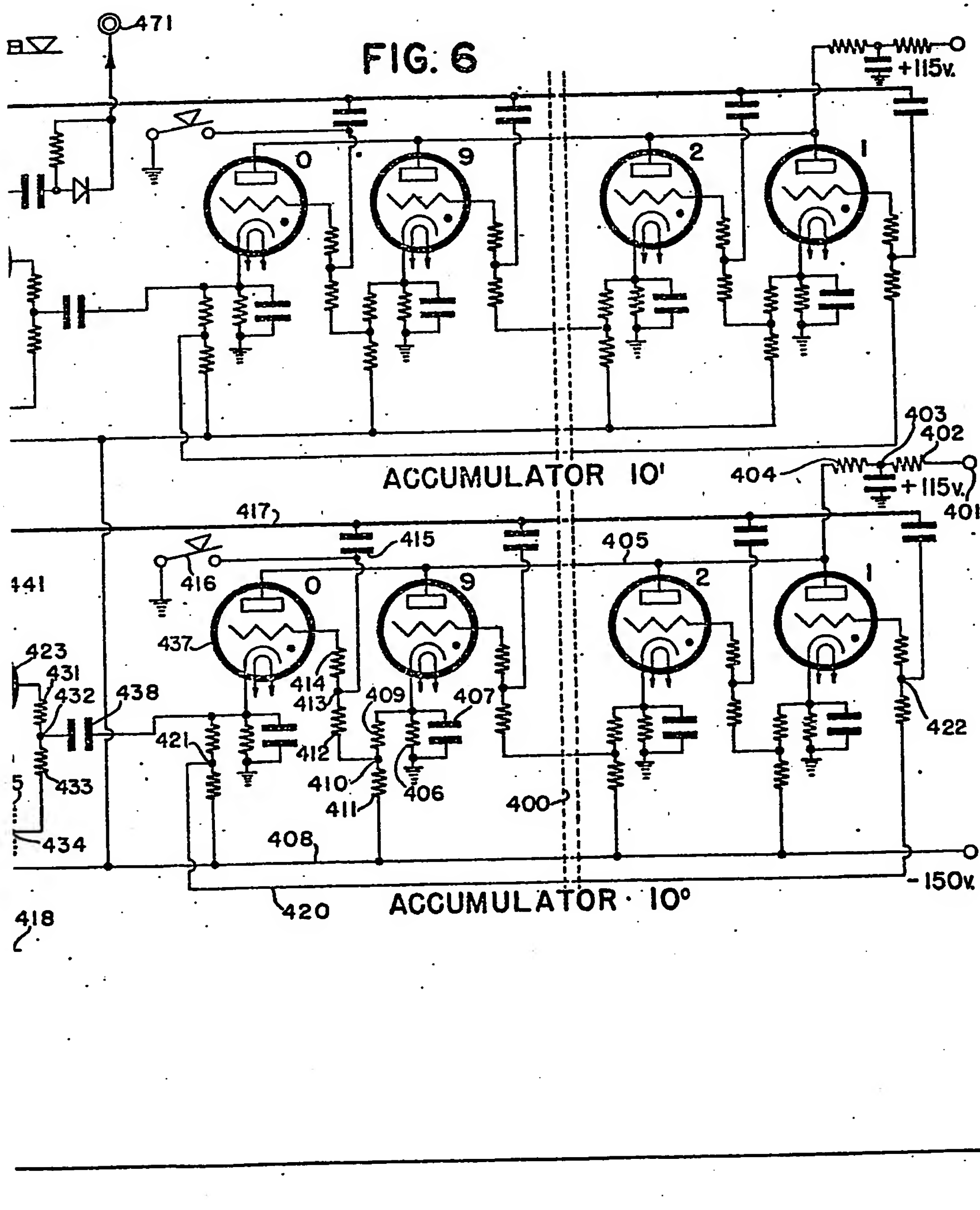
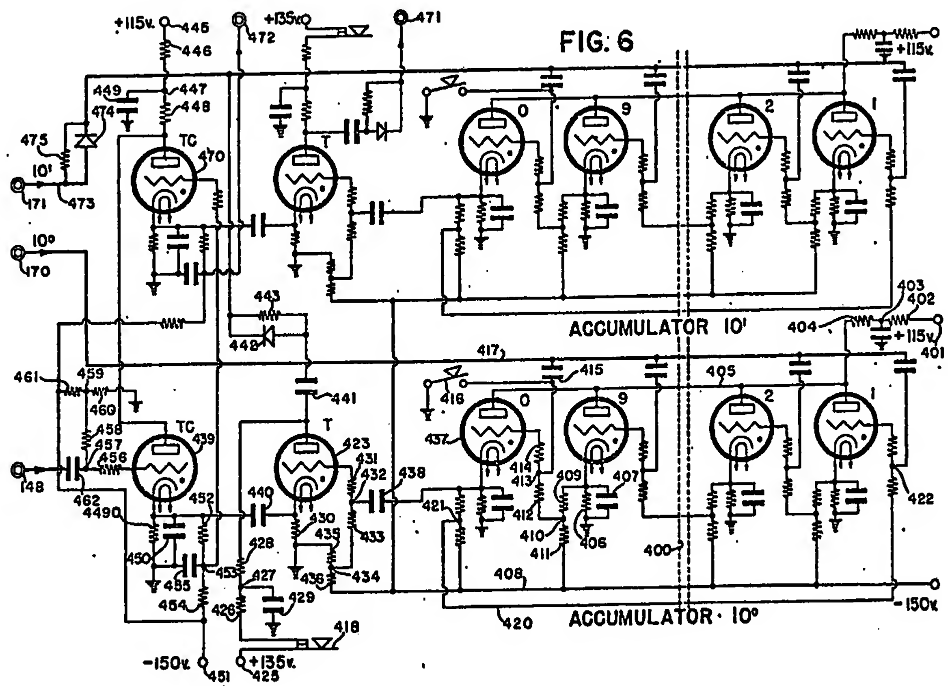

471
+115v.
0
9
2
1
ACCUMULATOR 10'
403
402
404
+115v.
401
417
415
405
416
441
437
423
431
432
438
414
413
409
407
422
421
412
410
406
433
411
400
434
408
-150v.
420
ACCUMULATOR · 10°
418

FIG. 6



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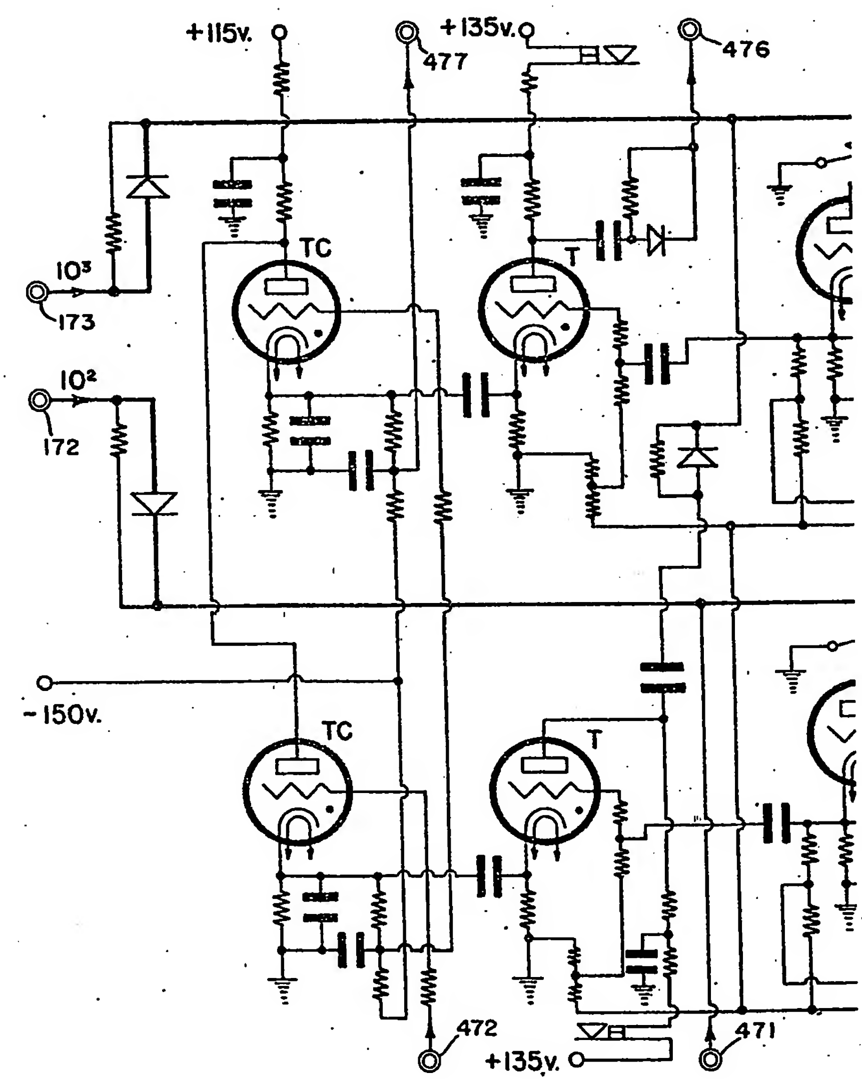


+115v.
+135v.
477
476
TC
T
10³
173
10²
172
-150v.
TC
T
472
+135v.
471

FIG. 7

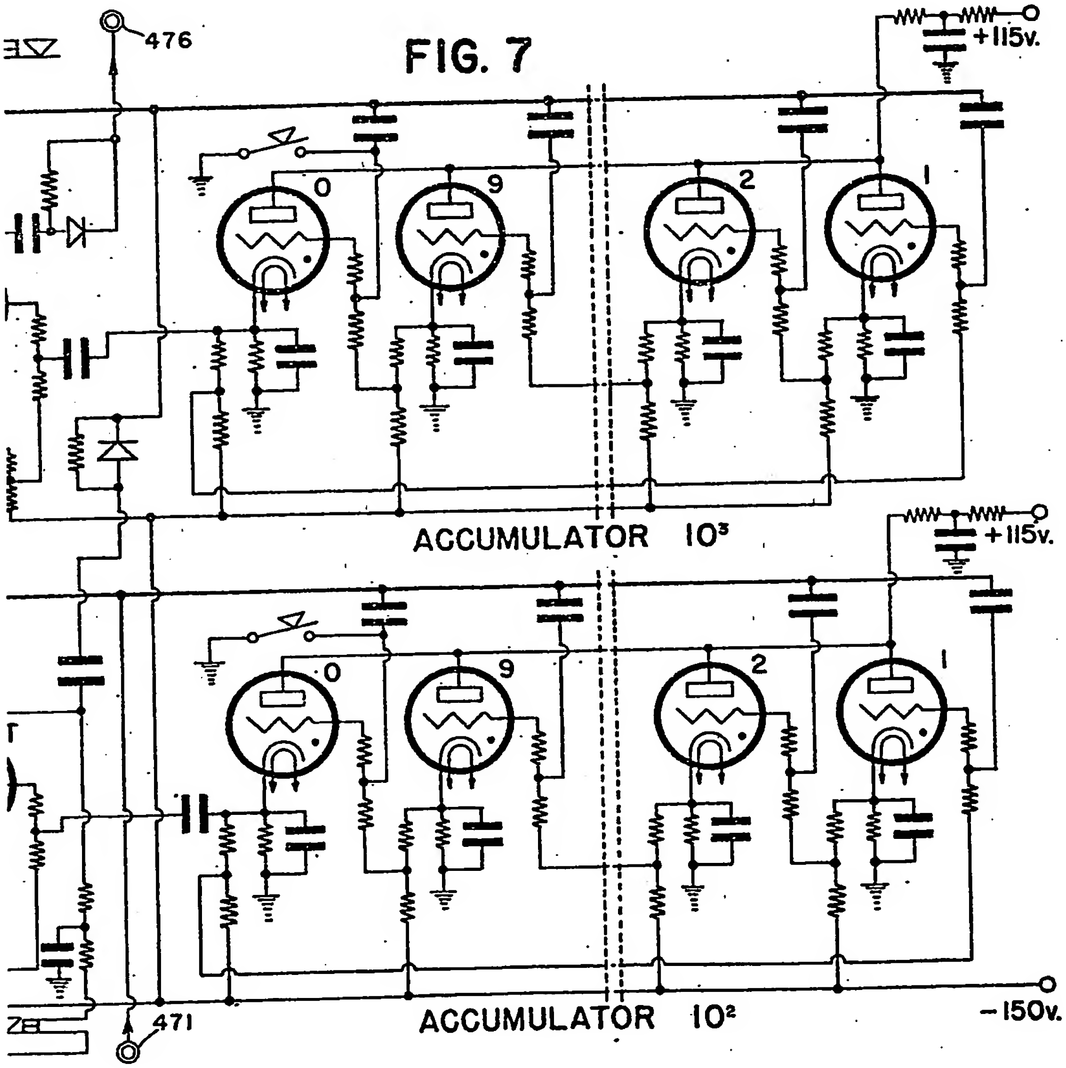
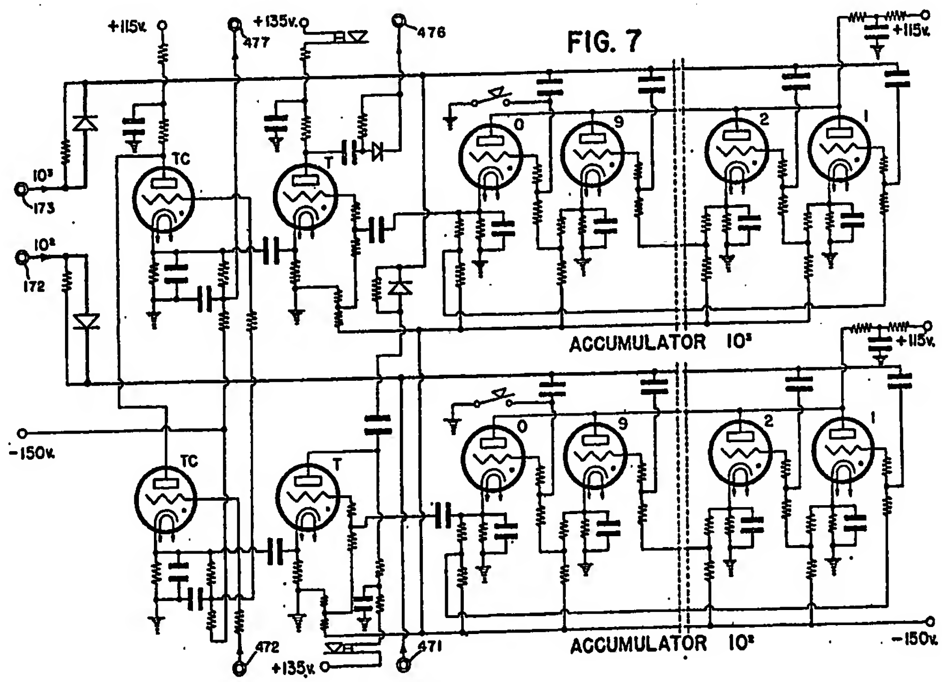

476
+115v.
0
9
2
1
ACCUMULATOR 10³
+115v.
0
9
2
1
471
ACCUMULATOR 10²
-150v.

FIG. 7



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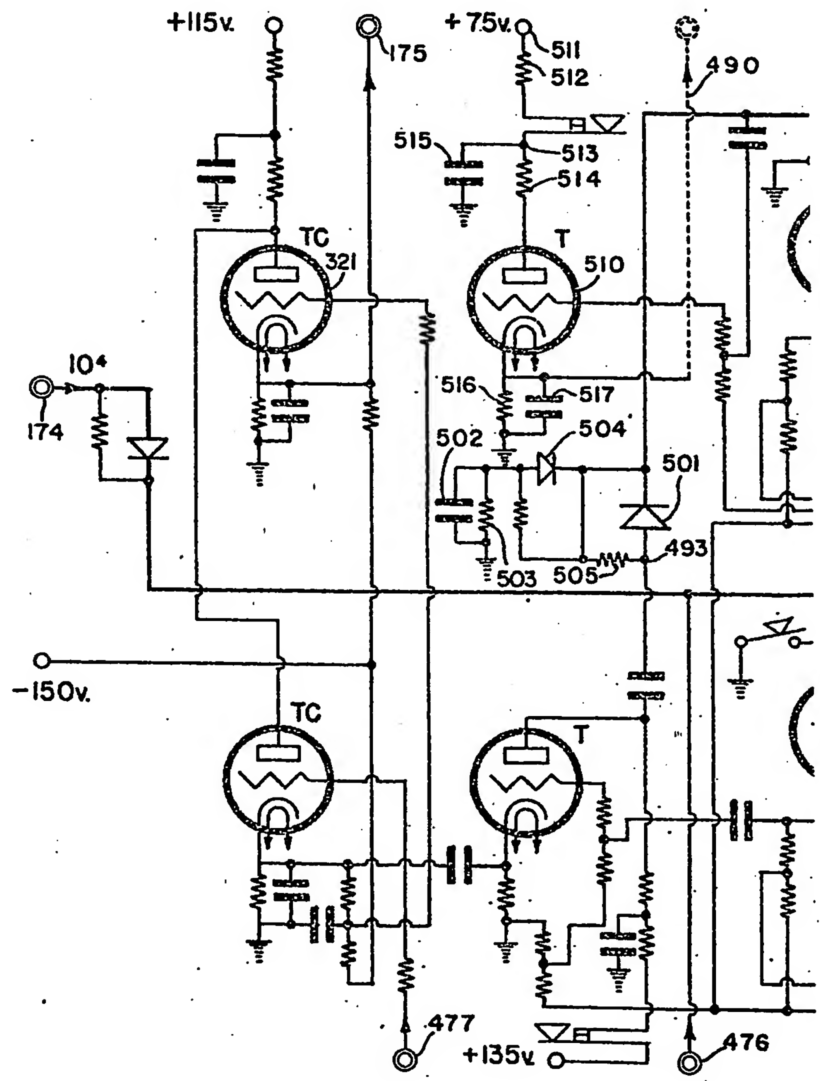


+115v.
175
+75v.
511
512
490
515
513
514
TC
321
T
510
10⁴
174
516
517
502
504
501
493
503
505
-150v.
TC
T
477
+135v.
476

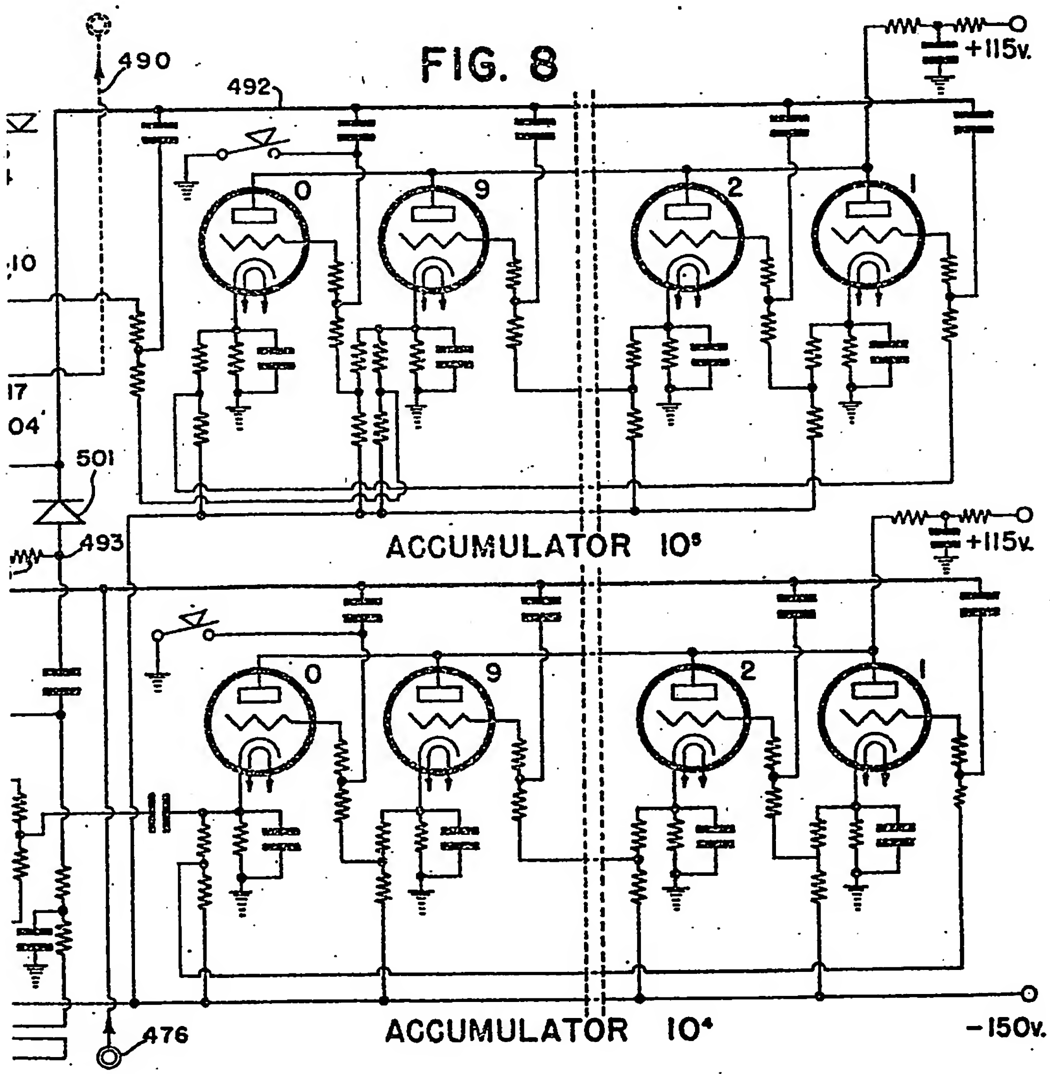
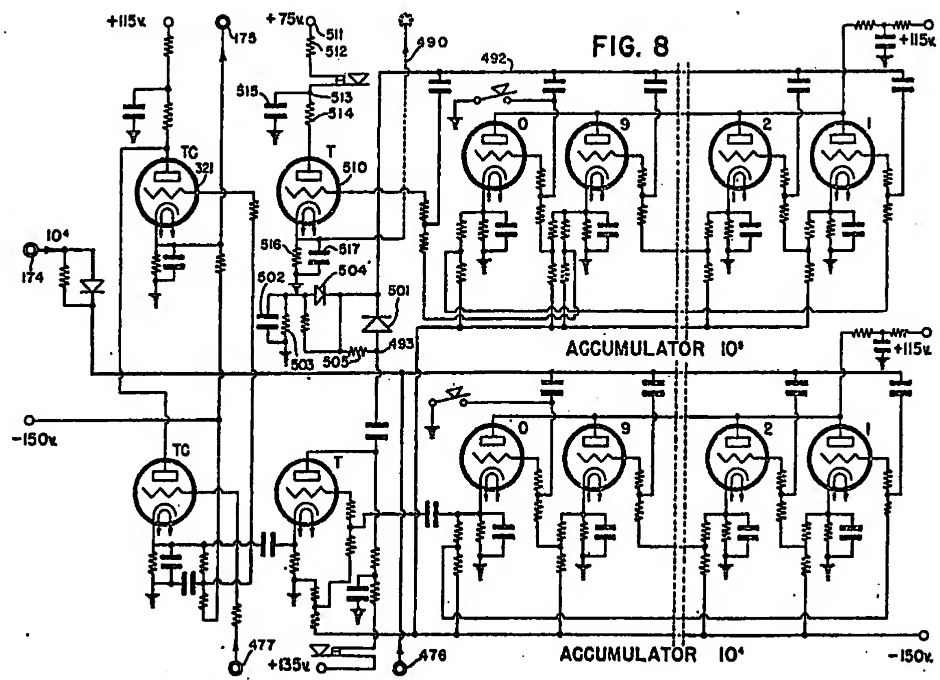

490
492
+115v.
0
9
2
1
10
17
04
501
493
ACCUMULATOR 10⁵
+115v.
0
9
2
1
476
ACCUMULATOR 10⁴
-150v.

FIG. 8

FIG. 8



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